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THE FIRE AT BALTIMORE.

The city of Baltimore (Md.) has been visited by a conflagration paralleled but few times in the history of the world. Acre after acre of splendid business buildings have been swept away, but with admirable resolution the city is already planning a reconstruction and reorganization. Foremost in the army of rehabilitation are the telegraph, telephone and light and power companies, upon which so much rests in the way of public service. In an incredibly short period of time blocked avenues of communication were reopened, and this resourcefulness and energy are worthy of all praise.

ELECTRIC CAR CONTROLLERS.

The movements of every electric car are controlled by two mechanisms—the electric controller and the brake mechanism. The former governs the starting and running of the car, and the latter brings it to a stop or prevents the car from getting beyond control on down grades.

Need for Starting Resistance.

The electric controller of to-day differs greatly from the types first put into use, so far as its construction and operation are concerned, but it utilizes the same controlling principles. The motor equipment of any car can move that car at a certain definite speed, depending, of course, upon the weight of the car and the character of the track, and also depending upon the electrical pressure supplied by the trolley wire or the conductors from which power is taken. If a car is running at a speed lower than the normal the motors will draw from the trolley wire a larger current than taken by them at the normal speed, and this larger current speeds up the car until it reaches its steady velocity. The greater the difference between the speed at which the car is moving and this normal speed, the larger will be the current drawn from the wire, and the greater the effort of the motors to speed up; consequently, when a car is standing still, the motors would draw such a current from the trolley wire that the car would be started forward violently, with great discomfort to all on board, and probably the safety devices installed to prevent excessive currents from passing through the motors would operate, and cut off the supply. To prevent this effect, starting resistances are used. These are connected in the electrical circuit, so that the current taken by the motors must pass through them; and as by offering a resistance to the flow of current they prevent this from reaching excessive values, the car will thus be allowed to start easily. As the car starts, the resistances are cut out by the motorman until all are removed from the circuit and normal speed is attained.

Cutting out Starting Resistance.

In the early car equipments these resistances were usually built up of coils of iron wire, and by means of an arm traveling over a number of metallic contacts, each contact being connected to some point of the wire, the latter was cut out very gradually. To-day such gradual starting is not thought necessary, and the resistance is usually divided into two or three sections and is removed in as many motions of the controller, the controller being the improved form of apparatus for making the contacts necessary for cutting out the starting resistance. The controller is also made use of to make the necessary changes in connections of the motors, in order that the direction of motion of the car may be reversed. This controller consists of a vertical spindle, on which is mounted a series of cylinders carrying

brass strips, which, when the controller handle is turned, come into contact with brass springs mounted on the back of the controller case, these springs being connected to the wires running to the motors, to the starting resistance, to the trolley pole, and one to some point of the truck, so as to make metallic contact through the wheels with the running rails. On turning the controller handle different combinations of motors and resistances are made, in sequence until the two motors are connected directly between the trolley wire and the running rail.

Series Parallel Control.

Since, as stated above, the speed of a car varies with the electrical pressure applied, where two motors are mounted on one car, current may be made to pass, first through the one motor, and then through the second. In this way each motor receives only one-half of the total electrical pressure, and the car, therefore, will run at but half speed. This arrangement is extremely advantageous for cars moving through city streets, and less energy is wasted if a car be started with the motors first in this arrangement, and then, after it has come up to half speed, they be connected so that each will receive the full pressure. This is what is known as the series parallel control.

Multiple Unit Train Control.

This method of controlling cars is very effective and reliable for single cars; but when heavy trains, moved by powerful motors, are to be operated, it is difficult to handle, in a device of this description, the heavy currents taken by the motors in operation. Moreover, it would not be easy to adapt such a device to controlling motors on more than one car at a time. A number of years ago the necessity for accomplishing this was recognized, and as a result the several so-called multiple unit train control systems have been developed. These operate in various ways, but they all make use of the same principle—that is, the motorman or engineer does not operate directly the device for making the necessary changes in the electrical connection, but, by moving the controller handle in the cab, he causes the necessary connections to be made elsewhere on the car. This controlling apparatus may consist of a small electric motor or electro-magnets, or of a compressed-air device, and the arrangement is always such that connections may be made between the several cars of a train, so that the movement of the controller handle in any one cab causes corresponding connections to be made in the motor circuit of each car, and the train moves forward as a unit. The motorman, then, does not operate the controlling apparatus of the train any more than he applies the brakes by hand. In the latter case he controls the air which applies the brakes, and in the former he controls an electric circuit or an air pipe which makes the necessary electrical connections. This method of control has many advantages. The cars may be operated singly or in trains, the difficulty of handling large currents in switching devices is minimized, all wires carrying heavy currents are kept beneath the car and the motor cars may be placed as far apart as desired and the propelling effort distributed throughout the train—a method of moving trains which has some distinct advantages over the one large locomotive.

THE ACTION OF THE ELECTROLYTIC RECTIFIER.

An interesting apparatus, which has attracted some little attention of late, is the so-called electrolytic rectifier. This device depends for its action upon the peculiar behavior of aluminum when used as the anode of an electrolytic cell, when it acts as if it formed an electric check valve, allowing current to enter it from the solution, but preventing all but a small current from passing into the solution from the plate itself. This action has been known for some time. It was observed by Buff as early as 1875, and received more or less attention from physicists until 1897, when its use to rectify alternating currents was suggested by Pollak and by Gratz, the latter proposing an arrangement of four cells connected in a rectangle, which allowed both halves of an alternating-current wave to be utilized. Others have since worked upon the problem, and there are to-day several rectifiers on the market which employ this principle. Various solutions may be used such as the carbonates and phosphates of sodium or ammonium and salts of certain organic acids.

Theories of the Phenomenon.

But while the actual behavior of aluminum used in this way has been investigated pretty thoroughly, there is a difference of opinion respecting the actual process by which the action takes place. In 1877 Beetz investigated the matter, and concluded that the aluminum became coated with a layer of hydroxide. This was supposed to be a non-conductor, and to insulate the plate from the electrolyte. Upon reversing the current, this hydroxide coating is wholly or partially destroyed, and the current is allowed to pass to the plate. Oberbeck and Streintz, considering the film on the aluminum plate to be a non-conductor, thought it possible that the plate and the solution formed a condenser. In fact a fairly satisfactory condenser may be made by means of two aluminum plates immersed in a suitable electrolyte. Dr. Guthe, from his experiments, was led to believe that the behavior of the plate was due to a film of gas on the anode, which adhered to the plate, insulating it from the solution; but, upon reversal of the current, this gas combined with the hydrogen liberated, and allowed the current to reach the plate.

A Recent Investigation.

A recent contribution to this subject has been made by Mr. S. R. Cook, of Columbus, Ohio. The theories advanced seeming unsatisfactory to him, he undertook a careful investigation, and publishes the results of the first part of his work in the *Physical Review* for January. Mr. Cook's experiments consisted in measuring the applied voltage, the current flowing, and the counter-electromotive force developed at the surface of the plate. He found that within certain limits of temperature and applied voltage, the counter-electromotive force amounted to eighty-five to ninety-five per cent of the applied. There was found to be a critical voltage; for, if this were exceeded, the counter-electromotive force decreased and the current increased rapidly. This critical value depends upon the temperature, decreasing with an increase of temperature. At higher voltages the whitish coating

on the aluminum plate changes to a dark crystalline substance, having the appearance of corundum. If the high pressure is maintained for a considerable time, this coating is apparently dissolved by the solution. The effect of higher temperatures is to allow a greater current to pass through the apparatus. In all cases there is a slight current—which may be called leakage current—which passes from the aluminum plate into solution, and this current increases rapidly with high temperatures, depriving the cell of its value as a rectifier.

Mr. Cook's Conclusion.

The author's work leads him to the conclusion, that the action of aluminum is not dependent upon the coating of hydroxide formed on its surface acting as a high resistance. Nor does he think that it is due to a film of gas operating in the same way He believes that the coating formed, while not being an insulation in the sense of protecting the plate completely from the electrolyte, is, nevertheless, a poor conductor and is impervious to the anions; and as these radicals can not reach the plate, they accumulate at the surface of the coating, and thus set up a counter-electromotive force. Upon reversal of the current, the cathion readily passes to the plate, allowing the current to flow. The effect of high voltages, Mr. Cook believes, is to leave openings through which the cathions may penetrate to the aluminum. High temperatures also affect this coating, with the same result. In other words, Mr. Cook attributes the rectifying action, not to condenser action, nor to the formation of an insulating coating, but to an effect which may be compared to the action of a semi-permeable membrane, allowing the cathions to pass freely but holding back the anions.

RAISING THE EFFICIENCY OF POWER GENERATION.

Every suggestion which promises at all to raise the efficiency of power generation deserves attention, and in this connection the suggestions made by Mr. E. C. Warren, in the *Engineering Magazine* for February, are interesting. Mr. Warren's plan for effecting economy in fuel consumption is to burn oil under pressure in a chamber, admitting for this purpose the necessary quantity of air, also under pressure. The combustion chamber is surrounded by water, to prevent radiation, and the products of combustion are mixed with the steam thus formed. In this way it is hoped to reduce the temperature of the resulting mixture to a point where it may be used in an engine which will not require water-jackets. The varying demands upon the generator are to be taken care of by automatic governors, controlling the supply of oil and air; and the construction of the generator, as outlined, is simple, allowing of numerous refinements for avoiding loss. The inventor believes that by this plan it should be possible to drive an engine similar to the steam engine, and he estimates that the efficiency of conversion obtained should be something like forty-five per cent.

Advantages Sought by the Process.

The aim here is to retain the advantages of the steam engine, but, by improving the method of obtaining gas under pressure, to raise the efficiency up to, or even surpass, that of the gas engine. In order to accomplish the former, gases are raised to a high temperature in an improved form of boiler or generator. By mixing the products of combustion with the steam, it is hoped to save much of the heat that formerly went up the chimney, and by mixing the steam with the gases, the temperature of the gases is to be lowered to a point where they may be used in a steam engine cylinder without the addition of water-jackets. In the system proposed the great loss will take place at the engine exhaust, and the point to be determined is, whether the heat carried away by the exhaust gases, is less than the loss taking place in the water-jacket of the gas engine.

STEEL CARS FOR THE SUBWAY.

The report that an order has been placed for 200 steel cars to be used in the New York subway has caused one of the New York daily papers to question whether the move is a wise one, and to raise several objections to the use of steel for this purpose. It is said that steel cars are noisy, that moisture condenses upon the inside, and that while in the event of an accident the steel plates would not fly into splinters, they would crumple up and, as they could not be cut away with an axe, they would hinder rescue work. These are all questions to be considered in the design of the cars, and should not be insurmountable, and much might be said both for and against the use of all steel cars.

Effect of Car Body Being an Electrical Conductor.

But to another objection to the use of steel car bodies which is put forward by the same paper as serious, exception may be taken. This is that the metal, being a conductor, may become alive from the partial or complete breakdown of the insulation of the electric wiring, and that this condition would be extremely dangerous, if not fatal, to the occupants of the car. We think our contemporary is unnecessarily apprehensive on this score. The steel body of the car will most certainly be metallically connected to the truck, and through the latter to the running rails. In other words, there will be an excellent electrical connection from the car body to the ground; and, therefore, it will be impossible for the former to have an electrical potential much, if anything, above that of the earth. Passengers will thus be protected from shocks due to contact between the metal car body and the electric wiring.

Effect of Defective Insulation on Electric Wiring.

What possibility there will be of electrical contact between the conducting wires and the steel body remains to be demonstrated. The wiring on the present cars is being put in in such a way as to prevent the cables from coming in contact with the car body; and if the latter be made of steel, even greater care, if possible, will be taken, because, should such contact take place, the effect would be what is technically known as a dead short-circuit, and certainly all circuit-breakers or other protective devices on the conductors feeding that section of the track on which the car is at the time of the accident would be opened. How satisfactory steel cars will prove can hardly be predicted, but so far as there being danger to passengers from electrical shocks, there would seem to be no risk.

CALCULATION OF TRANSMISSION LINES.

BY ALTON D. ADAMS.

Calculations to determine the sizes of conductors for electric transmission lines are all based on the fundamental law discovered by Ohm, which is that the electric current flowing in a circuit at any instant equals the electric pressure that causes the current divided by the electric resistance of the circuit itself, or current = pressure ÷ resistance.

Substituting in this formula the units that have been selected because of their convenient sizes for practical use, it becomes, amperes = volts ÷ ohms, in which the ohm is simply the electrical resistance, taken as unity, of a certain standard copper bar with fixed dimensions.

The ampere is the unit flow of current that is maintained with the unit pressure of one volt between the terminals of a one-ohm conductor. When this formula is applied to the computation of transmission lines the volts represent the electric pressure that is required to force the desired amperes of current through the ohms of resistance in any particular line, and these volts have no necessary or fixed relation to the total voltage at which the line may operate. Thus, if the total voltage of a transmission system is 10,000, it may be desirable to use 500, 1,000 or even 2,000 volts to force current through the line, so that one of these numbers will represent the actual drop or loss of volts in the line conductors when the number of amperes that represents full load is flowing. As it is a law of every electric circuit that the rate of energy transformation of electric energy to heat or work in each of its several parts is directly proportional to the drop of voltage therein, it follows that a drop of 500 or 1,000 or 2,000 volts in the conductors of a 10,000-volt transmission line at full load would correspond to a power loss of five or ten or twenty per cent, respectively. Any other part of 10,000 volts might be selected in this case as the pressure to be lost in the line. Evidently no formula can give the number of volts that should be lost in line conductors at full load for a given power transmission, but this number must be decided on by consideration of the items of line efficiency, regulation and the ratio of the available power to the required load.

Having decided on the maximum loss of volts in the line conductors, and knowing the full voltage of operation, the power and consequently the number of amperes delivered to the line at maximum load, the resistance of the conductors may then be calculated by the formula, amperes = volts ÷ ohms. Thus, if the proposition is to deliver 2,000,000 watts or 2,000 kilowatts to a two-wire transmission line with a voltage of 20,000, the amperes in each wire must be represented by 2,000,000 ÷ 20,000 = 100. With a drop of ten per cent or 2,000 volts, in the two line conductors, their combined resistance must be found from, 100 = 2,000 ÷ ohms, and the ohms are therefore twenty. If the combined length of the two conductors is 200,000 feet, corresponding to a transmission line of a little under twenty miles, the resistance of these conductors must be 20 ÷ 200 = 0.1 ohm per 1,000 feet. From a wire table it may be seen that a No. 1/0 wire of copper, B. & S. gauge, with a diameter of 0.3249 inch, has a resistance of 0.1001 ohm per 1,000 feet at the temperature of ninety degrees Fahrenheit, a little less at lower temperatures, and is thus the required size. Obviously, the resistance of twenty ohms is entirely independent of the length of the line, all the other factors being constant, and wires of various sizes will be required for other distances of transmission.

It is often convenient to find the area of cross-section for the desired transmission conductor instead of finding its resistance. This can be done by substituting in the formula, amperes = volts ÷ ohms, the expression for the number of ohms in any conductor, and then solving as before.

Electrical resistance in every conductor varies directly with its length, inversely with its area of cross-section, and also has a constant factor that depends on the material of which the conductor is composed. This constant factor is always the same for any given material, as pure iron, copper or aluminum, and is usually taken as the resistance in ohms of a round wire one foot long and 0.001 inch in diameter, of the material to be used for conductors. Such a wire is said to have an area in cross-section of one circular mil, because the square of its diameter taken as unity is still unity, that is, 1 × 1 = 1. In like manner, for the convenient designation of wires by their areas of cross-section, each round wire of any size is said to have an area in circular mils equal to the square of its diameter measured in units of 0.001 inch each. Thus, a round wire of 0.1 inch diameter has an area of 100 × 100 = 10,000 circular mils, and a round wire one inch in diameter has an area of 1,000 × 1,000 = 1,000,000 circular mils. The circular mils of a wire do not express its area of cross-section in terms of square inches, but this is not necessary since the resistance of a wire of one circular mil is taken as unity. Obviously, the areas of all round wires are to each other as are their circular mils.

From the foregoing it may be seen that the resistance of any round conductor is represented by the formula, ohms = $l \times s \div$ circular mils, in which l represents the length of the conductor in feet, s is the resistance in ohms of a wire of the same material as the conductor but with an area of one circular mil and a length of one foot, and the unknown circular mils are those of the required conductor. Substituting the quantity, $l \times s \div$ circular mils, for ohms in the formula, amperes = volts ÷ ohms, the equation, amperes = volts ÷ ($l \times s \div$ circular mils), is obtained, and this reduces to circular mils = amperes $\times l \times s \div$ volts. For any proposed transmission all of the quantities in this formula are known, except the desired circular mils of the line conductors. The constant quantity s is about 10.8 for copper, but is conveniently used as eleven in calculation, and this allows a trifle for the effects of impurities that may exist in the line wire.

The case above considered, where 2,000 kilowatts were to be delivered to a transmission line at 20,000 volts, and a loss of 2,000 volts at full load was allowed in the line conductors, may now be solved by the formula for circular mils. Taking the resistance of a round copper wire 0.001 inch in diameter and one foot long as eleven ohms, and substituting the 100 amperes, 2,000 volts and 200,000 feet of the present case in the formula, gives circular mils = (100 × 200,000 × 11) ÷ 2,000 = 110,000. The square root of this 110,000 will give the diameter of a copper wire that will exactly meet the conditions of the case, or the more practical course of consulting a table of standard sizes of wire will show that a No. 1/0 B. & S. gauge, with a diameter of 0.3249 inch, has a cross-section of 105,500 circular mils, or about five per cent less than the calculated number, and is the size nearest to that wanted. As this No. 1/0 wire will give a line loss at full load of about 10.5 per cent, or only one-half of one per cent more than the loss at first selected, it should be adopted for the line in this case.

The formula just made use of is perfectly general in its application, and may be applied to the calculation of lines of aluminum or iron or any other metal just as well as to lines of copper. In order

to use the formula for any desired metal, it is necessary that the resistance in ohms of a round wire of that metal one foot long and 0.001 inch in diameter be known and substituted for s in the formula. This resistance of a wire one foot long and 0.001 inch in diameter is called the specific resistance of the substance of which the wire is composed. For pure aluminum this specific resistance is about 17.7, for soft iron about sixty and for hard steel about eighty ohms. The use of these values for s in the formula will therefore give the areas in circular mils for wires of these three substances, respectively, for any proposed transmission line. In the same way the specific resistance of any other metal or alloy, when known, may be applied in the formula.

The foregoing calculations apply accurately to all two-wire circuits that carry continuous currents, whether these circuits operate with constant current, constant pressure or with pressure and current both variable. Where circuits are to carry alternating currents, certain other factors may require consideration. Almost all transmissions with alternating currents are carried out with three-phase, three-wire, or two-phase, four-wire, or single-phase, two-wire circuits. Of the entire number of such transmissions, those with the three-phase, three-wire circuits are in the majority, next in point of numbers come the two-phase transmissions, and lastly a few transmissions are carried out with single-phase currents. The voltage of a continuous-current circuit, by which the power of the transmission is computed, and on which the percentage of line loss is based, is the maximum voltage operating there, but this is not true for circuits carrying alternating currents. Both the volts and amperes in a circuit carrying alternating current are constantly varying between maximum values in opposite directions along the wires. It follows from this fact that both the volts and amperes drop to zero as often as they rise to a maximum. It is fully demonstrated in books on the theory of alternating currents, that with certain ideal constructions in alternating generators, and certain conditions in the circuits to which they are connected, the equivalent, or, as they are called, the virtual values of the constantly changing volts and amperes in these circuits are 0.707 of their respective maximum values. Or, to state the reverse of this proposition, the maximum volts and amperes, respectively, in these circuits rise to 1.414 times their equivalent or virtual values. These relations between maximum and virtual volts and amperes are subject to some variations with actual circuits and generators, but the virtual values of these factors, as measured by suitable volt and ampere-meters, are important in the design of transmission circuits, rather than their maximum values. When the volts or amperes of an alternating circuit are mentioned, the virtual values of these factors are usually meant unless some other value is specified. Thus, as commonly stated, the voltage of a single-phase circuit is the number of virtual volts between its two conductors, the voltage of a two-phase circuit is the number of virtual volts between each pair of its four conductors, and the voltage of a three-phase circuit is the number of virtual volts between either two of its three conductors.

Several factors not present with continuous currents tend to effect the losses in conductors where alternating currents are flowing, and the importance of such effects will be noted later. In spite of such effects, the formulæ above discussed should be applied to the calculation of transmission lines for alternating currents, and then the proper corrections of the results, if any are necessary, should be made. With this proviso as to corrections, the virtual volts and amperes of circuits carrying alternating currents may be used in the formulæ in the same way as the actual volts and amperes of continuous current circuits. Thus, reverting to the above example, where 2,000 kilowatts was to be delivered at 20,000 volts to a transmission line in which the loss was to be 2,000 volts, the kilowatts should be taken as the actual rate of work represented by the alternating current, and the volts named as the virtual volts on the line. The virtual amperes will now be 100, as were the actual amperes of continuous current, and the size of line conductor for a single-phase alternating transmission will therefore be 1/0, the same as for the continuous current line. If the transmission is to be carried out on the two-phase four-wire system, the virtual amperes in each of these wires will be fifty instead of 100, as the power will be divided equally between the two pairs of conductors, and each of these four wires should have a cross-section in circular mils just one-half as great as that of the No. 1/0 wire. The required wire will thus be a No. 3 B. & S. gauge, of 52,630 circular mils, this being the nearest standard size. In weight the two No. 1/0 wires, and the four No. 3 wires are almost equal, and they should be exactly equal to give the same loss in the single-phase and the two-phase lines. For a three-phase circuit to make the transmission above considered, each of the three conductors should have an area just one-half as great as that of each of the two conductors for a single-phase circuit, the loss remaining as before, and the nearest standard size of wire is again No. 3, as it was for the two-phase line. This is not a self-evident proposition, but the proof can be found in books devoted to the theory of the subject. From the foregoing it is evident that while the single-phase and two-phase lines require equal weights of conductors, all other factors being the same, the weight of conductors in the three-phase line is only seventy-five per cent of that in either of the other two. Neglecting the special factors that tend to raise the size and weight of alternating-current circuits, the single-phase and two-phase lines require the same weight of conductors as does a continuous current transmission of equal power, voltage and line loss. It should be noted that in each of these cases the factor l in the formula for circular mils denotes the entire length of the pair of conductors for a continuous current line, or double the distance of the transmission with either of the alternating-current lines.

Having found the circular mils of any desired conductor, its weight per 1,000 feet can be found readily in a wire table. In some cases it is desirable to calculate the weight of the conductors for a transmission line without finding the circular mils of each, and this can be done by a modification of the above formula. A copper wire of 1,000,000 circular mils weighs nearly 3.03 pounds per foot of its length, and the weight of any copper wire may therefore be found from the formula, pounds = (circular mils $\times$ 3.03 $\times$ l) $\div$ 1,000,000, in which pounds indicates the total weight of the conductor, l, its total length, and the circular mils are those of its cross-section. This formula reduces to the form, circular mils = (1,000,000 $\times$ pounds) $\div$ (3.03 $\times$ l), and if this value for circular mils is substituted in the formula above given for the cross-section of any wire, the result is (1,000,000 $\times$ pounds) $\div$ (3.03 $\times$ l) = (l $\times$ amperes $\times$ 11) $\div$ volts. Transposition of the factors in this last equation brings it to the form, pounds = (3.03 $\times$ l^2 $\times$ amperes $\times$ 11) $\div$ (1,000,000 $\times$ volts), which is the general formula for the total weight of copper conductors when l, the length of one pair, the total amperes flowing, and the volts lost in the conductors are known for either a continuous current, a single-phase, or a two-phase four-wire line.

If the value of l, 200,000, of amperes, 100, and of volts, 2,000, for the transmission above considered, are substituted in the formula for total weight, just found, the result is pounds = $(3.03 (200,000)^2 \times 100 \times 11) \div (1,000,000 \times 2,000)$, which reduces to pounds = 66,660, the weight of copper wire necessary for the transmission with either continuous, single-phase or two-phase current. With three-phase current the weight of copper in the line for this transmission will be seventy-five per cent of the 66,660 pounds just found. One or more two-wire circuits may be employed for the continuous current, or for the single-phase transmission, and if one such circuit is used the weight for each of the two wires is obviously 33,660 pounds. For a two-phase transmission two or more circuits of two wires each will be used, and in the case of two circuits, if all four of the wires are of equal cross-section, as would usually be the case, the total weight of each is 16,830 pounds. If the transmission is made with one three-phase circuit, the weight of each of the three wires is 16,830 pounds, and their combined weight, 50,490 pounds of copper. In each of these transmission lines the length of a single conductor in one direction is 100,000 feet, or one-half of the length of the wires in a single two-wire circuit. For the two-wire line the calculated weight of each conductor amounts to $66,660 \div 200 = 333.3$ pounds per 1,000 feet. For a two-phase four-wire line and also for a three-phase three-wire line, the weight of each conductor is $16,830 \div 100 = 168.3$ pounds per 1,000 feet. On inspection of a table of weights for bare copper wires it may be seen that a No. 1/0 B. & S. gauge wire has a weight of 320 pounds per 1,000 feet, and being much the nearest size to the calculated weight of 333 pounds should be selected for the two-wire circuit. It may also be seen that a No. 3 wire, with a weight of 159 pounds per 1,000 feet, is the size that comes nearest to the calculated weight of 168 pounds, and should therefore be employed in the three-wire, and the four-wire circuits, for two and three-phase transmissions. Either a continuous current, single-phase, two-phase or three-phase transmission line may of course be split up into as many circuits as desired, and these circuits may or may not be designed to carry equal portions of the entire power. In either case the combined weights of the several circuits should equal those above found, the conditions as to power, loss and length of line remaining constant. It will be noted that the formulæ for the calculation of the circular mils and for the weight of the conductors in the transmission line, lead to the selection of the same sizes of wire, as they obviously should do.

Several laws governing the relations of volts lost, length and weight of line conductors may be readily deduced from the above formulæ. Evidently the circular mils and weight of line conductors vary inversely with the number of volts lost in them, so that doubling this number of volts reduces the circular mils and weight of conductors by one-half. If the length of the line changes, the circular mils of the required conductors changes directly with it, but the weight of these conductors varies as the square of their length. Thus, if the length of the line conductors is doubled, the cross-section in circular mils of each conductor is also doubled, and each conductor is therefore four times as heavy as before. Should the length of the conductors and also the number of volts lost in them be varied at the same rate, the circular mils of each conductor remain constant, and its weight increases directly with the distance of transmission. Thus with the same size of line wire, both the number of volts lost and the total weight are twice as great for a 100 as for a fifty-mile transmission. If the total weight of conductors is to be held constant, then the number of volts lost therein must vary as the square of their length, and their circular mils must vary inversely as the length. So that if the length of a transmission line is doubled, the circular mils for conductors of constant weight are divided by two, and the volts lost are four times as great as before. Each of these rules assumes that the watts and voltage delivered to the line are constant.

The above principles and formulæ apply to the design of transmission lines for either continuous or alternating currents, but where the alternating current is employed certain additional factors should be considered. One of these factors is inductance, by which is meant the counter-electromotive force that is always present and opposed to the regular voltage in an alternating-current circuit. One effect of inductance is to cut down the voltage at that end of the line where the power is delivered to a substation, just as is also done by the ohmic resistance of the line conductors. Between the loss of voltage due to line resistance and the loss due to inductance, there is the very important difference that the former represents an actual conversion of electrical energy into heat, while the latter is simply the loss of pressure without any material decrease in the amount of energy. While the loss of energy in a transmission line depends directly on its resistance, the loss of pressure due to inductance depends on the diameter of conductors without regard to their resistance, on the length of the circuit, the distance between the conductors, and on the frequency or number of cycles per second through which the current passes. As a result of these facts, it is not desirable or even practicable to use inductance as a factor in the calculation of the resistance or weight of a transmission line. On transmission lines, as ordinarily constructed, the loss of voltage due to inductance generally ranges between 25 and 100 per cent of the number of volts lost at full load because of the resistance of the conductors. This loss through inductance may be lowered by increasing ~~reducing~~ the diameter of individual wires, though the resistance of all the circuits concerned in the transmission remains the same, by bringing the wires nearer together and by adopting smaller frequencies. In practice the volts lost through inductance are compensated for by operating generators or transformers in the power plant at a voltage that ensures the delivery of energy in the receiving stations at the required pressure. Thus, in a certain case, it may be desirable to transmit energy with a maximum loss of ten per cent in the line at full load, due to the resistance of the conductors, when the effective voltage at the generator end of the line is 10,000, so that the pressure at the receiving station will be 9,000 volts. If it appears that the loss of pressure due to inductance on this line will be 1,000 volts, then the generators should be operated at 11,000 volts, which will provide for the loss of 1,000 volts by inductance, leave an effective voltage of 10,000 on the line, and allow the delivery of energy at the substation with a pressure of 9,000 volts, when there is a ten per cent loss of power due to the line resistance.

Inductance not only sets up a counter-electromotive force in the line, which reduces the voltage delivered to it by generators or transformers, but also causes a larger current to flow in the line than is indicated by the division of the number of watts delivered to it by the virtual voltage of delivery. The amount of current increase depends on both the inductance of the line itself and also on the character of its connected apparatus. In a system with a mixed load of lamps and motors there is quite certain to be some

inductance, but it is very hard to predetermine its exact amount. Experience with such systems shows, however, that the increase of line current due to inductance is often not above five and usually less than ten per cent of the current that would flow if there were no inductance. To provide for the flow of this additional current, due to inductance, without an increase of the loss in volts because of ohmic resistance, the cross-section of the line conductors must be enlarged by a percentage equal to that of the additional current. This means that in an ordinary case of a transmission with either single, two or three-phase alternating current, the circular mils of each line wire, as computed by the formulæ above given, should be increased by five to ten per cent. Such increase in the cross-section of wires of course carries with it a like rise in the total weight of the conductors for the transmission. If wire of the cross-section computed with the formulæ is employed for the alternating-current transmission, inductance in an ordinary case will raise the assumed line loss of voltage and power by five to ten per cent of what it would be if no inductance existed. Thus, with conductors calculated by the formulæ for a power loss of ten per cent at full load, inductance in an ordinary case would raise this loss to somewhere between 10.5 and eleven per cent. As a rule it may therefore be said that inductance will seldom increase the weight of line conductors, or the loss of voltage and power therein, by more than ten per cent, while the usual figures are less than this.

When an alternating current flows along a conductor its density is not uniform in all parts of each cross-section, but the current density is least at the centre of the conductor, and increases toward the outside surface. This unequal distribution of the alternating current over each cross-section of a conductor through which it is passing increases with the diameter or thickness of the conductor, and with the frequency of the alternating current. By reason of this action the ohmic resistance of any conductor is somewhat greater for an alternating than for a continuous current, because the full cross-section of the conductor can not be utilized with the former current. Fortunately, the practical importance of this unequal distribution of alternating current over each cross-section of its conductor is usually slight, so far as the sizes of wires for transmission lines are concerned, because the usual frequencies of current and diameters of conductors concerned are not great enough to give the effect mentioned a large numerical value. Thus, sixty cycles per second is the highest frequency commonly employed for the current on transmission lines, and these lines seldom contain conductors larger than a 4/0 wire of B. & S. gauge. With a wire of this size, and the current frequency named, the increase in the ohmic resistance for alternating over that for continuous current does not reach one-half of one per cent.

Having calculated the circular mils or weight of a transmission line by the foregoing formulæ, it appears that the only material increase of this weight required by the use of alternating current is that due to inductance. This increase can not be calculated exactly beforehand because of the uncertain elements in future loads, but experience shows that it is seldom more than ten per cent of the calculated size or weight of conductors.

An Electrolytic Rectifier and Interrupter.

At the recent meeting of the Northwestern Electrical Association a communication was received from W. B. Churcher, describing the Churcher alternating-current rectifier.

This device consists of a single jar containing two aluminum electrodes and one electrode of platinum or other inactive material. The alternating current in the rectifier is supplied to the two aluminum plates from the secondary terminals of a transformer, and the converted uni-directional pulsating current is drawn from the inactive electrode, and a terminal tapped in at the middle of the secondary winding of the transformer. This arrangement rectifies both half waves of the alternating current.

In operation the central tap of the transformer is the positive terminal of the direct-current side, current passing from this point to the motor or other apparatus to be supplied, and thence to the inactive electrode in the cell. Used in this way, the direct-current voltage is limited to about seventy, being about half that of the alternating potential applied to the cell. The latter is found not to operate well with voltage of more than 150 between the two aluminum plates. To obtain higher voltages, two or more cells may be connected in series. The voltage on the direct-current side may be controlled advantageously by the use of an adjustable inductance on the alternating-current side.

By constructing a rectifier of this type with small aluminum electrodes, the apparatus behaves as an interrupter, as well as a rectifier. It is said that the interrupted direct currents obtained in this way are very effective for operating Rœntgen-ray apparatus.

The Race Meet of the American Power-Boat Association.

A race will be held under the auspices of the American Power-Boat Association on Decoration Day, May 30, 1904, open to all boats whose owners are members of clubs which are enrolled in the association. All classes, which include naphtha, steam, electric and kerosene types, with a length not less than thirty-five feet and a water line not less than twenty-five feet are eligible. The course for the smaller classes will be confined to the waters of Manhassett Bay, making a start from the Manhasset Bay club-house, Long Island Sound. The course for the larger boats will be from the same starting line, out into the sound and return.

On June 23, 24 and 25, the first match for the American Power-Boat Association challenge cup for power boats will be held. The course will be from a starting line in the Hudson river, off the Columbia Yacht club-house, at Eighty-sixth street and Riverside Drive, borough of Manhattan, New York, and around a stake boat anchored up the Hudson river not more than twenty miles above the starting line, and return. The entries for this challenge cup race are the same as those mentioned for the race on May 30.

Mr. Anson B. Cole, Manhasset Bay Yacht Club, 63 Wall street, is the chairman of the committee on challenge cup.

Transactions of the American Society of Mechanical Engineers.

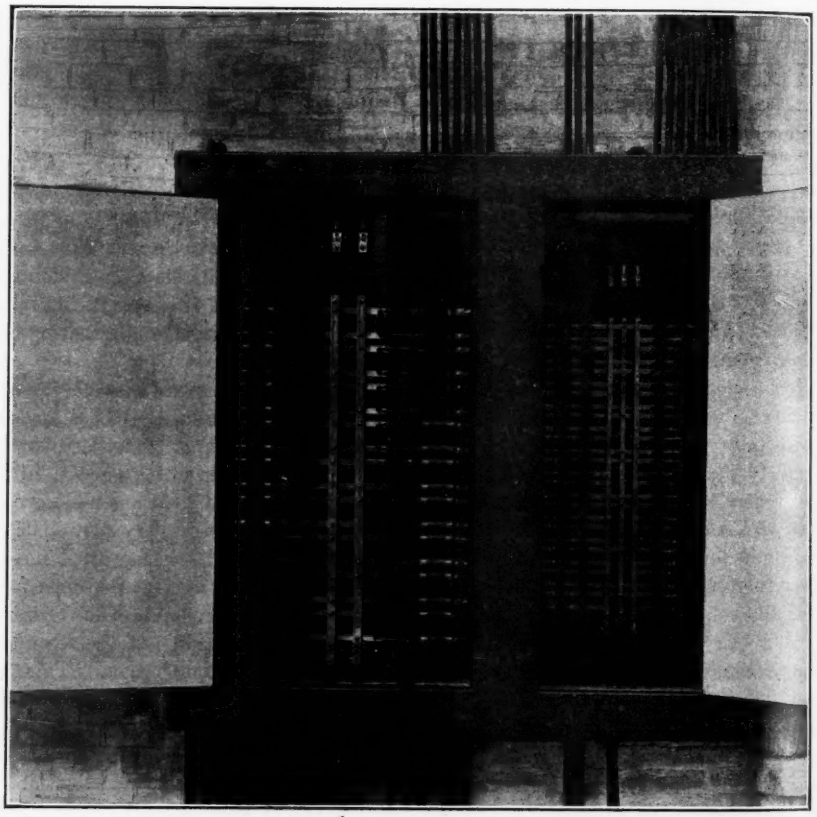
Vol. xxiv of the transactions of the American Society of Mechanical Engineers contains the proceedings of the forty-sixth meeting, held in New York city, December 2 to 5, 1902, and the forty-seventh meeting, held in Saratoga, N. Y., June 23 to 26, 1903. This is a bulky volume of over 1,500 pages, and contains fifty papers. Among those of interest to electrical engineers are the following: "Alternating-Current Motors for Variable Speed," by W. I. Slichter; "Rational Train Resistance Formula," by J. B. Blood; "Steam Turbine from an Operating Standpoint," F. A. Waldron; "The Use of a Surveying Instrument for Machine Shop Practice," C. C. Tyler; "Water and Heat Consumption of a Compound Engine at Various Powers," D. S. Jacobus; "Flywheel Capacity for Engine-Driven Alternators," W. I. Slichter.

Mechanical and Electrical Equipment of the Sackett & Wilhelms Lithographing and Printing Company.

PART II—ELECTRICAL.

CURRENT is generated at sufficiently above 230 volts to give that pressure at the power and lighting outlets. From the generators the leads and field wires are carried to the switchboard in separate pipe conduits under the floor. The dynamo leads are of stranded copper with rubber and braid covering and protected by a lead sheathing three-thirty-seconds of an inch thick. They are proportioned for a current-carrying capacity allowing a drop of not more than one volt between the generators and the dynamo switch lugs when running at full load. Two extra sets of conduit are in place to connect the future generators to the panels which will be added to the switchboard at that time. The current for power is distributed on a two-wire system and that for lighting on a three-wire system, a seven and one-half-kilowatt balancing transformer being used to equalize the load on the two sides. A 115-volt pressure is also used for charging the storage batteries on the electric automobile delivery wagons, a separate eleven-kilowatt balancer being used for that purpose.

The provision for the charging of the automobiles is a unique and interesting one. It is so arranged that from one to four automobiles may be charged at one time, any or all of which may be either in the stable or the courtyard, or part may be in one place and part in the other. This is made possible by the provision of four charging circuits, each having two terminals, one in the barn and one in the courtyard, but as connection is made by a double-throw switch, only one is active at a time. The charging switchboard is located near the fireproof vault in the basement. It is of marbleized slate one and one-half inches thick and has two panels each thirty inches wide by seventy-two inches high. The equipment on the two panels is similar and symmetrically arranged with respect to each other, the only difference between the two being that one has a voltmeter with a six-circuit switch and the other has an ammeter with a four-circuit switch. By means of the meter switches the pressure and current in any of the four charging circuits may be measured, or the voltmeter may be placed across either leg of the three-wire system to test its balance. The two-pole switches at the top of the panels control the two sides of the system, and the remainder of the equipment is in quadruplicate, one set serving each of the four charging circuits and including a 100-ampere fused double-throw switch, a single-pole circuit-breaker arranged to trip at underload as well as overload to automatically open the circuit when charging at too high a rate, a Cutler-Hammer charging rheostat to regulate the amount of current as the charging proceeds, and a signal lamp to indicate to an attendant that there is an automobile being charged.



A TYPICAL POWER AND LIGHTING DISTRIBUTING PANEL.

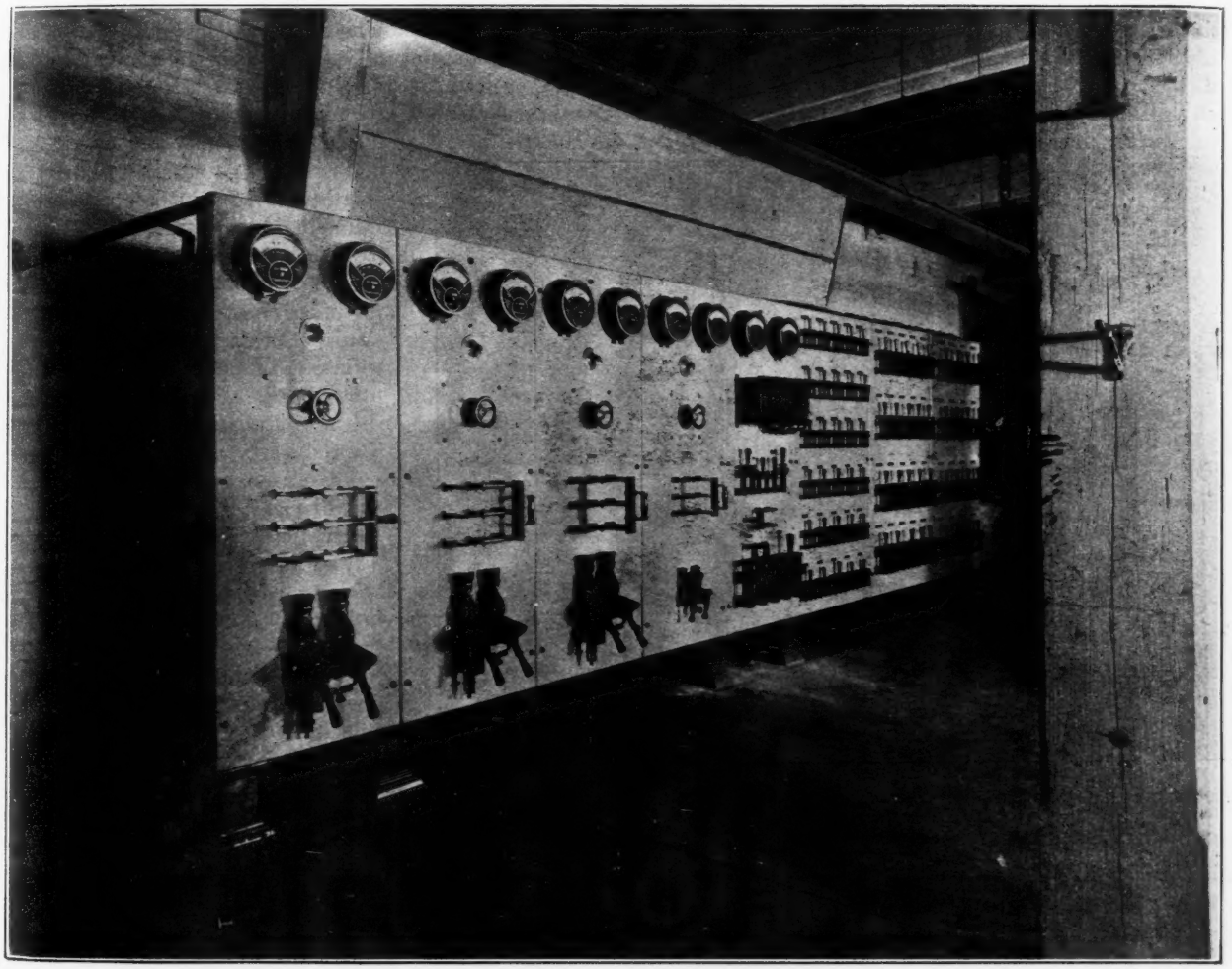
A view of the main switchboard, which is of gray Knoxville marble twenty-one feet four inches long by seven feet high, is shown. At present there are eight panels which, from right to left, are as follows: one for each of the two-kilowatt generators, one for the seventy-five-kilowatt and one for the twenty-five-kilowatt generators; a panel for the two balancers; a distributing panel for the lighting system, and two power distributing panels. Separate bus-bars are provided on the back of the generator panels for power and lighting, each consisting of a positive, negative and an equalizer bar. These may be connected together by a "throw-over" switch or either set may be connected to any one or more of the generators. To allow for the latter a double-throw, three-pole dynamo and equalizer switch is installed on each generator panel, the rest of the equipment consisting of a circuit-breaker in each lead, both connected together so that one will trip the other, a field rheostat, a voltmeter, an ammeter, and a radial voltmeter switch to connect the meter with any machine at will. By means of this switch the attendant starting up a generator may compare its voltage with that of the other machines before throwing it in and may do so without moving away from the panel. The balancer panel has two ammeters, one in each side of the lighting system; two starting boxes, one for each balancer, and the following switches: a double-pole, single-throw switch and a single-pole neutral switch for each balancer, an equalizer switch for the two balancers, a three-pole bus switch for the

eleven-kilowatt charging balancer and a two-pole switch controlling the lighting distribution from the seven and one-half kilowatt balancer.

The lighting service panel contains thirty three-pole single-throw feeder switches arranged in six horizontal rows of five each. The general scheme assigns the vertical rows from left to right to the basement, first, second, third and fourth floors, and the horizontal rows from the bottom to the top, to certain sections. Since three of these sections are but two stories high, the two right-hand switches on the three top rows are extras. Two of these are now used for the lights in the lower section, the boiler house and the others are spare switches. The switches on the power panels are all double-pole single-throw and have a similar arrangement to that on the lighting panel, but extended over two boards. The first has five switches for each of three sections, with the top row of five for extras, and the second four rows of four switches each for three other sections, with the right-hand switches and the top row for spares. It was not found feasible to adhere to this scheme strictly, a few special switches being necessarily out of place; however, it assists the attendant in locating a switch quickly and as all are labeled there is no chance for a mistake. The areas of contact of the switch clips and blades are proportioned for a current density not exceeding eighty amperes per square inch. All fuses are of the D & W enclosed pattern with "tell-tales" to indicate when they are burned out. Those for the dynamo and transformer panels are mounted on the rear of their respective panels. The fuses of the feeder switches are mounted on a special one and one-half inch terminal board on the wall at the rear of the switchboard, following an arrangement corresponding with that of the switches, thus avoiding all confusion.

The feeders from the board are taken in conduits under the floor to the terminal panel, thence in conduits along the walls, ceilings and pillars to the various power and lighting outlets. The mass of conduits crowded together where they start from the terminal board are concealed by a light removable sheet-iron casing, to avoid an otherwise disfiguring background for the switchboard. Twenty-five of the conduits contain three-wire feeders, leading from the switchboard to the switch-distributing centres of the lighting system, where three-wire panel boards are installed. Each panel board has a separate feeder, both being identified by the same number and serving one section of one floor. The capacities of the feeders vary according to the number of lights they supply, the smallest having a capacity of ten amperes, the largest 100, and the average, eight amperes.

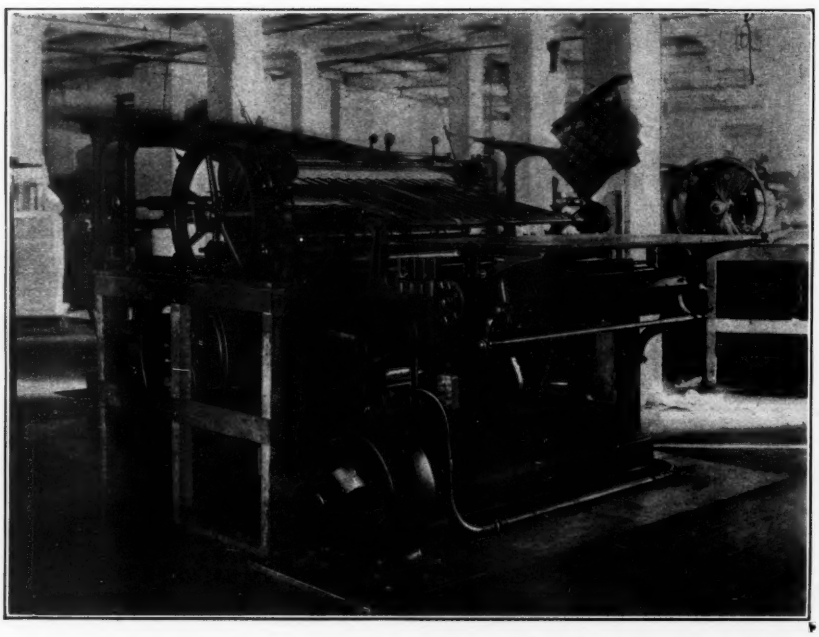
There are twenty-one two-wire 240-volt feeders for power service, which are run from the switchboard to the several points where the two-wire power panel boards are installed. Here again a single feeder serves a single section, and is numbered to correspond with the panel it leads to. The variation in the capacity of the feeders ranges from 100 to 320



MAIN SWITCHBOARD IN ENGINE ROOM, SACKETT & WILHELM LITHOGRAPHING AND PRINTING COMPANY.

amperes, the average being 190 amperes. The feeder conductors are stranded and have an extra heavy braided insulation for use in unlined conduits. They are proportioned to allow a drop in potential not to exceed five volts, when carrying full load current.

The distributing boards are of marbleized slate, one inch thick or over, according to the size. These are mounted in hardwood boxes, slate lined, fitted with swinging doors which are protected on the inside with sheet-iron coverings, and provided with lock and key. Each branch conductor has a double-pole copper knife switch with an enclosed fuse in each leg. The feeders enter at the bottom of the board, the bus-bars are vertical and the branch switches open and close horizontally. A typical arrangement and the method of mounting the power and lighting boards are illustrated in one of the half-tones. This shows a power panel on the left, with its two main bus-bars extending up along the middle of the board, and a lighting panel on the right similar in arrangement, except that it has three vertical buses.



THREE AND ONE-QUARTER HORSE-POWER MOTOR, DRIVING TWO-REVOLUTION TYPE PRESS.

The number of branch circuits leading from the lighting panels depends upon the amount of illumination demanded. Each one has a capacity of twenty-five amperes and supplies not more than ten sixteen-candle-power incandescent lights or two five-ampere arc lights. The branch switches on the power panels are of either fifty or 100-ampere capacity, and are of a number to allow one for each motor at present installed, with several spares for future additions. Like the feeders all branch circuits are run in unlined conduits. Those carrying lighting circuits are run along the ceiling of the sections in which the outlets are located. Each of the conduits for the motor circuits is carried from the power panel down through the floor and along the ceiling below to a point near the motor, where it is brought up through the floor and ends in a terminal box. The terminal boxes for plug receptacles and motor outlets are of hardwood, slate lined and provided with swinging doors hung on spring hinges. Lighting system terminal boxes are equipped with one fifty-ampere double-pole knife switch and one twenty-five-ampere receptacle, and motor outlet boxes with one double-pole knife switch of a rating suited to the nominal full-load current capacity of the motor.

As previously stated, the total number of incandescent lights supplied is about 900 and arc lights, 150. The power consumers include a total of sixty-six motors, aggregating 350 horse-power. Of these, sixty are of Crocker-Wheeler make; five, of General Electric, and one, of Milwaukee. Thirty are of seven and one-half horse-power and the remainder range in size from five to one-half horse-power. These are variously employed in the driving of grinding machines and bench saws; bronzing, embossing and cutting machines and stitchers; type, job, litho and transfer presses; plate-graining machines, ink grinders, etc. The job and transfer presses and some of the machines are group-driven, but the type and litho presses and the greater part of the machinery are driven individually.

Among the illustrations will be found a number of individual machines which show excellent applications of motor drive for their class of machinery. Connections are mostly by belt for the reason that slipping is often of advantage in saving both the machines and their motors from shock in ordinary running and more serious injury if anything goes wrong. The placing of the motor, as well as the methods by which the drives have been arranged, is especially to be commended. In all cases the saving of floor space has been made of second consideration to the placing of the motors in easily accessible situations, and yet they are noticeably unobtrusive and no menace to safety. Fair lengths between belt centres have been maintained, and large pulley diameters have been avoided by employing slow-speed motors. A feature that appeals to the orderly is the regularity with which similar machines have been located, as witnessed in the views of two lines of litho presses and one of type presses, shown with this and the preceding article. The most attractive side of this arrangement, however, is that it facilitates the handling of large quantities of work in a short time. In the matter of system, it may be said of all departments that they are most admirably coordinated to work in harmony for the filling of orders with the least delay.

The structural details of the building are due to the architect, Mr. C. H. P. Gilbert, of New York city, and the consulting engineer, Mr. Walter S. Timmis, of Brooklyn, who also acted as engineer for the mechanical and electrical features. Mr. Timmis is an expert on printing-press machinery, and remains on the grounds as the firm's consulting engineer. Mr. Arthur G. Stone, of Brooklyn, was the supervising builder, directing the construction work, and the following contractors, all of New York, installed the work indicated: Messrs. Hatzel & Buehler, the dynamo feeders and switchboard; Messrs. Weiderman & Conklin, the power and lighting circuits, and Messrs. Blackall & Baldwin, the motors.

Report of the Chief of the Bureau of Navigation, Navy Department.

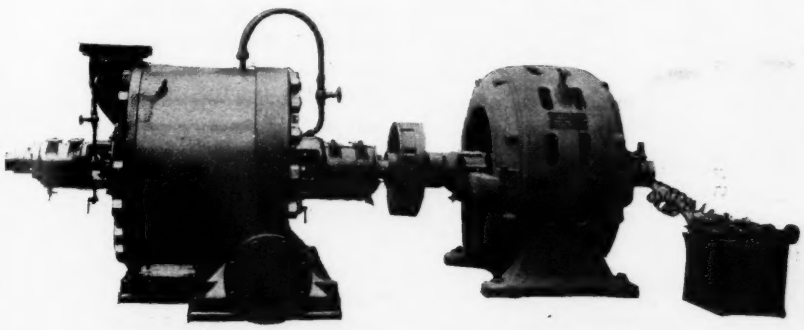
The report of the chief of the bureau of navigation, navy department, for 1903, is devoted principally to an account of the distribution and services of various government vessels during the past year.

AN ELECTRIC PUMPING STATION FOR THE KIMBERLEY MINES.

BY EMILE GUARINI.

An electric pumping station for the De Beers consolidated mines at Kimberley, South Africa, has been made by Mather & Platt. This consists of two centrifugal high-pressure pumps, coupled directly to two polyphase motors.

In these improved pumps water enters the wheel from the centre, whereas in the simple pumps it enters from the two sides, symmetrically avoiding axial thrust. The water then passes through curved passages and is discharged tangentially at the periphery into a stationary case. The latter carries it to an annular chamber in the body of the pump, where the speed is converted into pressure. From this chamber the water is discharged into pipes, when the pump is simple, while in the multiple pumps it passes into the second chamber and into the third and so on.



THREE-PHASE INDUCTION MOTOR DRIVING CENTRIFUGAL PUMP.

The Kimberley installation is double. The first unit consists of a centrifugal pump with four chambers, capable of raising 1,000 gallons of water per minute to a total height of 320 feet. The body of the pump is of cast iron. The vanes, the guides and the wheel are all of steel.

The pump is attached by a flexible coupling to a three-phase motor, fed from a fifty-cycle system at 220 volts. This motor develops 150 horse-power at 730 revolutions per minute, but can develop, if necessary, ten horse-power additional. Starting is accomplished by liquid rheostats with electrodes of sheet iron. The second group is formed of a centrifugal pump with two chambers, capable of raising 1,000 gallons of water per minute to a total height of 160 feet. It is driven through a flexible coupling by a three-phase motor of seventy-five horse-power, at 730 turns per minute, but the motor can develop eighty horse-power if need be. It is also started by means of a liquid rheostat, and is identical with the preceding group, except that the power is one-half.

The stator of the motor has eight poles. It is constructed of sheet iron, grooved for the conductors. The rotor has a definite winding, with slip rings, arranged for short-circuiting.

The arrangement for short-circuiting the rotor winding presents two important advantages: first, on starting, the current never exceeds half the normal current; and second, it avoids loss due to the brushes and resistances. This assures a high efficiency during starting and in operation. In virtue of the large diameter of the motor and the small number of poles, combined with the special form of slots, a high coefficient of power is obtained, even with relatively low output, although this result has not necessitated any sacrifice in the mechanical construction. The air-gap is two millimetres in length.

The efficiency is high, and the rise in temperature is very small. The latter point is important where motors are used for long periods of time, and in places where the air is renewed slowly. It is necessary to obtain an excellent balance of the revolving parts, and the absence of vibration shows that this has been accomplished by these machines.

The overload capacity of the motors is 100 per cent. In tests, the starting current was, for the large unit, 160 amperes per phase. This is raised from 320 to 330 amperes when lifting 320 feet. The efficiency of the motor was 92.5 per cent at 120 horse-power. The power-factor was ninety-three per cent, while from thirty per cent underload to thirty per cent overload the efficiency and the power-factor are more than ninety per cent.

The efficiency of the pumps at 1,000 gallons per minute was seventy-five per cent, and the combined efficiency of the pump and motor was 69.5 per cent. After eight hours of uninterrupted operation at full load the rise in temperature was only eighteen degrees centigrade. The figures obtained for the small group were also very favorable.

Thus, each day the superiority of electricity for operating mining machinery in general, and mining pumps in particular, is demonstrated. It is to be hoped that the day is not far distant when the mining world will show less disregard for this new auxiliary, which has such important advantages for mining work.

The Lamme Single-Phase Motor.

A British patent for improvements in electric motors was recently granted to Mr. B. G. Lamme, of the Westinghouse company, and is reprinted in the London *Electrician* for January 22, from which the following particulars are taken:

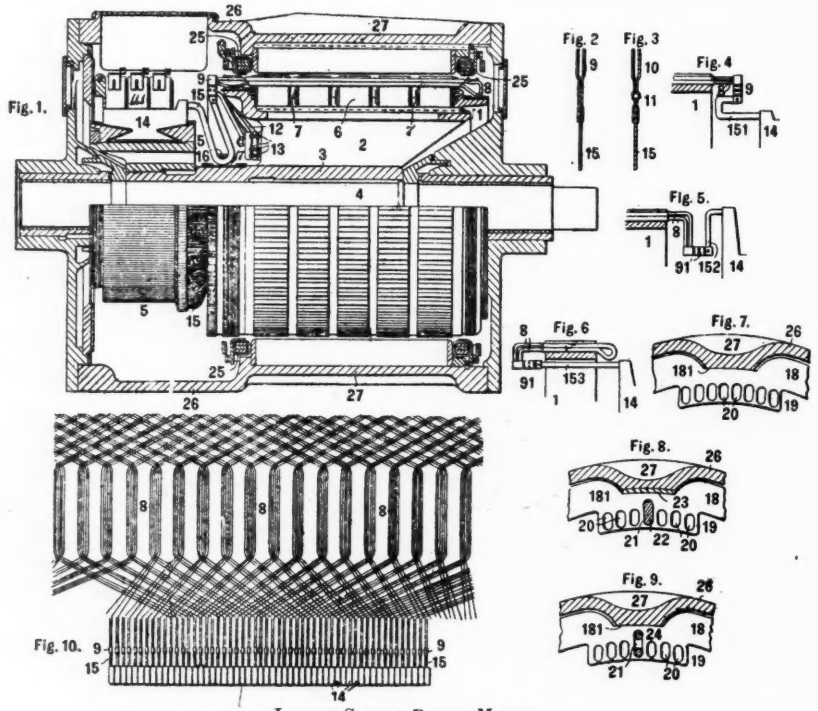
In order that the necessary torque may be obtained, it is essential that the inductance of the motor be not greater than a certain amount, as the effect of this is to reduce the current which can pass through the winding. Moreover, as the cross-induction of the armature through the poles acts with the self-induction of the field in limiting the flow of current, it is desirable that this also should be kept within proper limits. It follows that the self-induction of the motor as a whole should be relatively small with relation to the applied electromotive force. When this is the case, the counter-electromotive force is approximately equal to the applied electromotive force, or the inductance of the motor must be low as compared with the counter-electromotive force of the armature in normal working. To obtain this condition the number of line alternations must be small, and there must be a large number of poles and a high speed, and a small number of field ampere-turns and a relatively large number of armature ampere-turns. The ratio of field ampere-turns to armature ampere-turns has a minimum value, fixed by the proper operation of the motor itself. This ratio should be greater than one-half, and may sometimes be as high as three-quarters. This ratio being fixed, a definite relation between the alternations in the supply circuit, the number of poles of the motor and its rate of revolution exists. An average working value for this is, approximately, 0.625.

To obtain these low values of inductance of armature and field, a special construction is necessary. Thus, slots or holes may be cut in the body of each of the pole-pieces from end to end, transversely to the direction of rotation, the amount of iron left at the back of the teeth being that which is required for the desired

induction. The slots or holes may be closed or nearly closed at the pole-faces. The cross-section of iron in the poles is preferably such that but little magnetizing power is absorbed in addition to that required for the air-gap, until the current exceeds the normal rate of amperes of the motor. Beyond this normal current the teeth between the pole slots approach saturation rapidly. The cross flux from the armature may be limited, in addition to the slotting of the poles, by the interposition of a secondary circuit within the pole. This will oppose the magnetic flow which would tend to cross the slot.

The armature winding of the motor is of the closed-coil type, and is closed upon itself before being connected to the commutator, and relatively high-resistance leads are inserted between the winding and the respective commutator bars. The principal cause of excessive sparking in series motors of ordinary construction, when it is attempted to operate them on an alternating-current circuit, is due to the heavy currents flowing in the coils short-circuited through the brushes; but by means of these resistance leads the short-circuited currents are limited, and commutation is brought under control.

The motor requires a relatively large number of poles, compared with the direct-current series motor of corresponding size; and as the conditions of good commutation demand that the armature circuits of the motor be connected in parallel, and that the number of turns between consecutive bars be small, it follows that the actual voltage is low, compared to a direct-current machine. As the motor has a low voltage, the currents flowing will be high, and may be too large for advantageous handling in a controller. Further, the line voltage may be too high for use directly in the controller, so that it may be advantageous first to transform the line potential down to a pressure suitable for the controller, and then to transform this to a still lower voltage for the motor. It is possible, however, by means of one or more transformers, to operate a motor of any voltage by a controller adapted to any voltage from a supply circuit of any voltage. A convenient method of control consists in connecting a main transformer across the supply circuit, its secondary being included with the motor circuit, but having included in series the secondary of a series transformer, the primary of which derives current either directly or indirectly from the main circuit, and is capable of adding to or subtracting from the electromotive force developed in the secondary of the main transformer. The motors on a car may be connected either in series or in parallel.



LAMME SINGLE-PHASE MOTOR.

In the accompanying drawings, Fig. 1 is a view, partially in side elevation and partially in longitudinal section, of a motor constructed according to these ideas. Figs. 2 and 3 show the resistance leads for connecting the commutator segments to the armature windings, Figs. 4 and 5 showing modifications of these conditions. Figs. 7, 8 and 9 are detailed views of different forms of field magnet core construction. Fig. 10 shows the developed winding of the motor.

In Fig. 1, 2 is the armature spider, of which 3 is the hub or sleeve. This is extended to receive the commutator cylinder 5. The core of the armature is built up in the usual manner of thin plates, with proper spaced ventilating ducts, and provided with slots, which in this case are seventy-two in number. The coils are strap conductors, there being six conductors in each slot, the coils spanning from the first to the ninth slot, and so on. The winding is cross-connected by means of the connectors 12 attached to the balancing rings 13. One of the high-resistance lead wires is shown at 15. Variations in the form of this are shown in Figs. 4, 5 and 6. In the latter case the connecting lead passes through the armature spider to the commutator at the end opposite to the ends of the armature conductors.

Figs. 7, 8 and 9 show suitable types of pole-faces. In Fig. 8, 21 is a bar or plate of copper or other good conducting material, but serves as closed secondary to reduce the armature inductance due to cross-magnetization. In Fig. 8 is also shown a copper plate 23, which acts in the same way. In Fig. 9 the construction is the same as that shown in Fig. 8, except that a single turn of wire 24, constituting a closed coil, is placed in the middle slot, instead of the bar or plate shown in Fig. 8.

The claims for this motor are:

1. A single-phase alternating-current series-wound motor in which the ratio of the field magnet self-induction to the armature counter-electromotive force is approximately equal to the ratio of the line alternations to armature alternations.

2. A single-phase alternating-current series-wound motor having a closed-coil parallel-wound armature with relatively high-resistance leads, connecting the armature coils with the commutator bars, and a field magnet, the poles of which have slots transverse to the direction of rotation of the armature, and with or without a closed conductor inserted in one of the slots.

3. For use with single-phase alternating electric currents having the ratio of the number of its field-poles to the number of current alternations per minute, approximately as 1 to 250, and having a ratio of field ampere-turns to armature ampere-turns, approximately as twenty to twenty-seven.

The last claim is for a motor constructed according to the above drawings.

WHAT INDUCEMENTS TO ENTER "LIGHT CURRENT ENGINEERING" ARE HELD OUT TO TECHNICAL STUDENTS?

BY JOSEPH B. BAKER.

The above title needs a word of explanation. By "light current engineering" is meant those branches of electrical engineering dealing with comparatively feeble currents, characteristic of the telephone, for example. There has been an impression, less current now than formerly, that the more dignified and "worth while" special careers in electrical engineering were those dealing with heavy work—railroads, power transmission and the like. Technical students have been frequently heard to express their preferred intention of taking up "heavy work" upon graduating. Such an attitude of mind, however, is hardly justified at present, in view of the almost incredible advances that have been made in branches of engineering work in which the technical and executive abilities of the engineer are called upon in the solution of problems involving multiplicity of detail—circuits and apparatus—rather than in problems of economical transmission of heavy currents or high voltages. In thinking of the openings especially attractive to men who have had the training of technical schools, the engineering fields of telephony, telegraphy and wireless telegraphy readily suggest themselves.

TELEPHONY.

It has been well said that the telephone engineer has had to be more different kinds of an electrical engineer than have any others of his craft. It is true that his big problems do not concern a coal-pile nor iron and copper losses; but he has to pass upon practically the whole range of commercial electrical machinery required, in small units, under the varying conditions of telephone installations, and, in addition, finds a familiar and extensive range of problems in the construction and operation of somewhat complex devices, worked through a multiplicity of special connections by delicately adjusted and comparatively feeble currents. It is certainly true that a vast deal of brilliant work, comparing favorably in achievement with any engineering work the world has ever seen, has been performed quietly and unobtrusively by American telephone men in the development of this great means of electric communication. Their work has been cut out for them at a fast pace, as may be partially understood when it is realized that the growth of Bell operating companies alone has for some years past been at the rate of twenty-five per cent, figured on each preceding year. These operating companies have for some years drawn largely upon the graduating classes of our technical schools. Graduates go in, in many instances, as "inspectors" with a broad round of duties, the faithful and capable performance of which means, sooner or later, widening of opportunity for many. We may positively affirm that any bright young fellow going in at about the graduating age and willing to put an effective pair of pliers in the pocket of his overalls and get to work in harmony with the *esprit de corps* that he finds existing in the construction and operating departments of most live telephone companies, stands to-day a better chance than ever of making his personality felt and securing his advancement. It must not be understood that the "overall period" is to last forever; it is merely an absolute essential of apprenticeship without which the telephone man's education is incomplete. To be able, later, to scheme upon and carry out the enlargement of a big, busy switchboard, without interruption of service; to meet the growth of traffic; to meet emergencies by getting rush work out of a gang of men, whether "out on the line" or upon switchboard cable work, or even by carrying a big exchange through the run of the traffic day after day with a varying and often inadequate force of operators; to keep things running smoothly under heavy loss of toll lines by blizzard "line breaks," by maintaining operating-room efficiency at its top notch and satisfying the impatient public—these things are a few among many opportunities for the display of ability of the first order. In the writer's opinion there is something peculiarly American in the way such difficulties as these have been met and solved, and the quality of the service held up to what it is, in the face of a never-ceasing, always accelerating growth of the telephone traffic.

The recent enormous strides that independent telephone companies have made, have undoubtedly added, more than proportionately, to the opportunities for advancement. It is a fact well known among telephone engineers that there has been a steady and brisk demand for quite young men, trained in the Bell school, to take jobs leading those who prove their special fitness up to positions of responsibility with independent companies; the latter competing briskly with the Bell in their need of such experience and trained abilities, by reason of their extraordinarily rapid extensions. The present striking success of the automatic telephone system is still further accelerating this demand; and this latest stimulus is practically sure to be maintained, in view of the revolutionizing effect of the introduction of machine telephone operating in increasing the availability of this service.

Particularly in the telephone field is it true that the opportunities are great for becoming an engineer by combining, with mature experience and acquired technical and executive ability, those things which can be learned "at the desk end," the business end, of any industrial concern. In the sterner conflict that is predicted as coming between the Bell and independent interests, by those who believe that the telephone service is a natural monopoly, to be an engineer measured by the above standard will mean the possession of commanding influence in this great traffic of electric communication.

TELEGRAPHY.

By this is meant the new telegraphy—the rapid, machine-handled sending of telegraph messages over existing lines, by methods more scientific than the present simple "Morse" worked by hand over lines whose traffic capacity is never pushed beyond that obtained by the quadruplex. In our opinion, the time can not be much longer postponed when the modern methods will replace the ancient and primitive "hammering of brass" at one end and "taking by sound" at the other end; the method of signaling by which our great telegraph service is operated to-day. With several distinct systems of high-speed telegraphy worked out not only experimentally but to a great extent practically by some of the most distinguished men in the electrical field, and further, with a public becoming enlightened upon modern, scientific possibilities in all directions, there is good reason to hope that this oldest of the great electrical arts may make application of improvements that will modernize it and bring its standard of working into harmony with other processes of traffic and manufacture that were themselves not long ago in a similarly imperfectly developed, comparatively primitive condition.

Under the operation of the great telegraph lines of the country—to which should be added the long-distance telephone lines as far as their use at night is concerned—by systems of transmission based upon scientific use of a connecting line in the latter's modern aspect as a means of directing rapidly succeeding signaling waves, there is at once opened a

vast field for technically trained young men. The achievements of wireless telegraphy have cast a strong light upon the value inherent in a connecting line between stations; a value that has been literally thrown away by the old methods of telegraphing, and which it may be the work of many young electricians of the immediate future to realize commercially by adapting terminal apparatus and signaling electromotive forces to the constants of these lines, whereby their traffic capacity will be enormously increased. The need of their expert services will begin when the general public has at last become tired of being obliged to regard the telegraph service as a sort of luxury, for sparing use in business or social communication, and has demanded its transformation into the handling of its business mail by wire, a feat not only possible but certain of achievement over our existing lines by a revolutionary departure from old methods. When the public finds, for example, that it need not wait the best part of four days for an ordinary written message to bring its reply in communication between Chicago and Boston, but that the business mail between those cities might easily be handled, overnight, at nominal cost and without any hardship of reductions of dividends of the telegraph companies, this revolution will begin. It was virtually predicted over eight years ago by an eminent telegraph engineer.[1]

WIRELESS TELEGRAPHY.

This subject may well serve to wind up the present list of opportunities for the student of "light currents." Problems, already partially solved experimentally, of tuning, of reaching distance, of multiplex working, etc., in the commercial development of space telegraphy, will all require the best skill that can be brought to bear for their commercial application in the near future. The pioneer work now being done by a few master minds is bound to be succeeded by the labors of many highly trained men placed in charge of the practical installation of stations, and with specialized experience in such work based upon their complete mastery of the theory of high-frequency oscillations in the technical schools. The field of "wireless" is so vast—without regard to the question of whether it is going to encroach upon that of wire telegraphy—the revolution that it effects in maritime affairs is so far-reaching that, after the storm of litigation which seems to be inevitably impending has cleared away, the broadcast sowing of wireless stations is likely to set in with a rush. At that period the services of a large body of technical graduates will be in demand, in the opening up of a field as broad and at least as important as the trolley system of the country, for example.

[1] See *Electrical Engineer*, New York, September 11, 1895, "The Struggle Between Telegraph and Telephone."

General Electric Company Wins Lamp Suit.

On February 2, 1904, Judge Brown, in the Circuit Court of the United States, District of Massachusetts, in the suit of the General Electric Company *versus* the Re-New Lamp Company and others, handed down a bill enjoining the use by the defendants of the complainant's trade-mark, "G. E.," on electric lamps. At a prior hearing, on a petition for a preliminary injunction, the defendants contended that the General Electric Company had placed within the stem of an electric lamp a non-removable label bearing the letters, "G. E.," as a device to hinder the defendants' business of repairing and renewing electric lamps; and that under color of a claim for the protection of a trade-mark, the complainant was in reality seeking to destroy the defendants' business. A preliminary injunction was denied, because of doubts whether the complainant's case was in substance an ordinary trade-mark case, and because of the novelty of the legal questions which would arise if the defendants should establish their contentions of fact. The defendants, by their answer in the present case, renewed their contention that the letters, "G. E.," in the stems of the lamp are non-removable, and were put in the stems not as a trade-mark, but in pursuance of a scheme to prevent the remaking of the lamps.

The opinion states that it must be held that the complainant's trade-mark, affixed to the inner stem of the lamp, is practically removable in the remaking of lamps, by applying certain processes. The opinion further states that it becomes doubtful if the complainant's officers were in any degree influenced to adopt the peculiar location of the trade-mark because they thought it non-removable in remaking. The complainant has shown good business reasons for applying its trade-mark, "G. E.," to some portion of an electric lamp.

Upon full hearing, the judge is of the opinion that the complainant's use of its trade-mark in the stem of the lamp is a natural and proper use, growing out of ordinary business considerations, and that it did not, in fact, tend to destroy the defendants' business or appreciably reduce their profits; and that there is not sufficient or substantial reason to justify the allegation that the complainant, either alone or in combination with others, did devise a scheme to attack the business of the defendants. The case, upon the facts, becomes a simple one. The complainant has a valid trade-mark. The defendants, without legal justification, put forth lamps bearing this trade-mark. Though they did so without any intent to deceive, and have been honorable in intention and business methods, and, as far as appears, have caused no actual deception, yet the use of this trade-mark in violation of its legal rights, entitled the complainant to an injuction, and a draught decree is to be presented accordingly.

New Process for Manufacture of Iron Alloys.

Ferrosilicon, ferromanganese or similar iron alloys are obtainable, according to a French patentee, says Oliver J. D. Hughes, consul-general, Coburg, Germany, in two operations, with the intermediate production of barium or other silicate or of a mixed oxide, and the ultimate production of baryta, strontia, soda, potash, or like oxide as a by-product. The barrium silicate, obtained by heating barium sulphate with silica and carbon in proper proportions in a glass furnace, or in an electric furnace which is worked at a moderate temperature, is heated with proper proportions of carbon and cast or wrought iron, ferric oxide, or manganese dioxide, giving the alloy, barium oxide, and carbon monoxide. This operation is performed in a closed electric furnace at a moderate temperature, passing the gas through a dust chamber. The furnace product is treated with hot water and yields barium hydrate. In a modified process manganese and iron oxides are partially reduced by heating either with sodium sulphate in an ordinary furnace or with barium sulphate and carbon in an electric furnace. The mixed oxides thus obtained are heated with carbon in an electric furnace. When soda is produced it may be volatilized completely from the electric furnace to a collecting chamber.

New Location of the Westinghouse Company's Baltimore Office.

Owing to the fire which swept the business district of Baltimore, the branch office in that city of the Westinghouse Electric and Manufacturing Company has been removed to 221 North Calvert street. The company's full force of representatives will be at this office to take care of all business addressed to this quarter.

The Conflagration at Baltimore.

On the morning of Sunday, February 7, a disastrous fire broke out in the business portion of Baltimore, Md. Owing to a series of unfortunate complications, the local fire department was unable to cope with the blaze, and it spread rapidly to such proportions that considerable help from neighboring cities had to be sought. In this case assistance came from as great a distance as New York city, and this outside help was a very material factor in stopping the progress of the flames.

At the present time it is impossible to estimate the great loss which has been occasioned to the city. The fire was confined chiefly to the business portion, and because of this the property loss is very high. A conservative estimate would seem to place this loss at about $150,000,000. The fire swept an area of some 140 acres, and completely wiped out the electric lighting, power, telephone and telegraph systems in the burned district.

For some time after the beginning of the fire the immense power-house of the United Electric Light and Power Company continued to give service throughout the city. It is extremely unfortunate that some of the heavily charged overhead wires caused a good deal of trouble in fighting the fire in its early stages. However, at about eight o'clock on the morning of February 8, the fire reached the power-house, consuming it entirely and destroying every piece of machinery.

The Chesapeake & Potomac Telephone Company had four exchanges in Baltimore. The largest of these—the main exchange on St. Paul street, was in the centre of the fire zone, and the building and contents were completely destroyed, but the company was able to save all of the records of traffic and organization. The building and contents were wholly covered by insurance, though the lines and apparatus at the subscribers' stations were not, so that there will not be a total loss. This exchange served about 7,500 stations, of which some 3,000 were in the burned district. About 7,500 subscribers were served by the exchanges which were not burned.

Mr. Union N. Bethell, president of the company, went down from New York on Sunday afternoon, and by noon on Monday had shipped all of the company's records of accounts to Washington, D. C., establishing an office in one of the business buildings of that city. The company rented two houses on St. Paul street, Baltimore, where communication could be established with other exchanges which were not in the burned area. It was fortunate in having a new switchboard, with a 4,500-line capacity, in Washington, ready to be installed in a new exchange in that city. Arrangements were made to have this board immediately shipped to Baltimore, and new cables run to connect the new switchboard with the old centre of distribution. Plans for making this service complete are now under way, and it is expected to have all the service cut in in a short time. All of the toll lines and long-distance circuits centred in the St. Paul street exchange, which was destroyed. These were all cut into the Mount Vernon exchange on Tuesday, so that the traffic to and from out-of-town points was established with very little delay. It is a peculiar coincidence that the new Mount Vernon, Madison and Gilmor exchanges, which are now carrying on the service, were opened on the Saturday evening preceding the conflagration. These exchanges are in new buildings, erected and equipped for the special purpose of serving the telephone institution. The lines of the Chesapeake & Potomac company in the burned district were principally underground, the company having planned during the past year to remove all of its poles, and all but a few of the lines had already been placed underground.

In planning for the restoration of service, the work will all be of first-class and substantial character, having in mind a permanent installation. This is in order not to interfere with the development of the company's system, which during 1903 was remarkable, there being a gain of over sixty-five per cent in the number of stations connected up.

The company received offers of assistance from every quarter, cable manufacturers and supply houses sending men to Baltimore with lists of apparatus ready for immediate use, from which the company might select. Although the company was extremely grateful for the generous proffers of aid, it was not found necessary to take advantage of any of these, as the material which the company's supply department had on hand and the general staff were sufficient to cope with even these extraordinary conditions. It was not even necessary to call for engineers from any of the other companies, although the Maryland Telephone Company, whose exchange was not burned, offered every assistance. It is understood that a large number of the subscribers of the Maryland company were in the burned district.

In order that there will be no delay in the Washington, D. C., installation, which was deprived of its board through this necessity, a duplicate order has been placed and work will go forward at this point without any interruption.

The Baltimore headquarters of the Postal Telegraph-Cable Company was in the Continental Building. This building, although in the heart of the fire, was not entirely destroyed, and it is expected that repairs will begin at once. All the wires of the company were underground, and by the night of Tuesday, February 9, all necessary connections were made to practically rehabilitate the system. The company opened temporary offices both north and south of the burned area. With the exception of some minor offices, everything is in practical business shape. The new Baltimore headquarters of the company is at 217 Calvert street.

All of the offices of the Western Union Telegraph Company, with the exception of four, were destroyed. During the height of the conflagration the company reestablished headquarters in portions of the city outside of the fire zone, and renewed its business. At six o'clock Tuesday morning, February 9, the wiremen of the Western Union company got through the fire lines and established their connections both north and south with Baltimore. Officials of the company expect that within four days the permanent headquarters will be established and business working as usual.

Finsen Light-Treatment.

U. S. Consul R. R. Frazier, at Copenhagen, Denmark, has reported recently on the Finsen Medical Light Institute, of Copenhagen, which was established in 1886 by Professor Niels R. Finsen. This is now a state institution, and 1,367 cases had received treatment up to May, 1903. A recently issued report, covering the first 800 cases of *lupus vulgaris*, showed that fifty-one per cent have been apparently cured, and that in thirty-five per cent of the cases the treatment has been satisfactory, and cure seems certain. In only five per cent has the treatment proved unsatisfactory. Nine per cent of the cases disappeared from observation.

The treatment consists in bathing the diseased surface with light from a special form of electric arc lamp. The method seems to be efficacious for most skin diseases, but less so for deep-seated cancers.

New York Electrical Society.

The 241st meeting of the New York Electrical Society will be held on Wednesday evening, February 17, at the American Institute, 19 West Forty-fourth street, New York city. Mr. Ralph D. Mershon will lecture on "The Gas Engine for Central Station Service."

INDUSTRIAL ELECTROCHEMISTRY AND ELECTROMETALLURGY—XI.

NOTES ON PROGRESS IN EUROPE AND AMERICA.

BY JOHN B. C. KERSHAW.

Cyanides and Nitrides.

The fixation of the nitrogen of the air in the form of nitric acid or nitrates has more than once been referred to in these series of notes, and in the ELECTRICAL REVIEW of February 21, 1903, and of January 30, 1904, some information was given respecting the industrial trials of such processes at Niagara Falls and at Fribourg, in Europe.

In this note, attention will be directed to other methods of attacking the same problem—the inventors in this case using the high temperature of the electric furnace as the means for obtaining the nitrogen of the air in the form of a cyanide or nitride.

The first process to which attention may be directed is protected by German patent No. 16,298 of 1902, and was described at the Berlin Chemical Congress of June, 1903. A mixture of lime and charcoal is heated to 2,000 degrees centigrade in an electric furnace, and nitrogen or air is led over the heated mass. A product named calcium cyanamide is obtained under these conditions, and from this, potassium or sodium cyanide can be prepared, by double decomposition with potassium or sodium chloride. Calcium cyanamide can also be employed as an artificial manure, and it is stated that it is already being placed on the market in Germany for this purpose, under the name of kalkstickstoff.

The second process is that of Chalmot, who has taken out an American patent for a somewhat similar process—in this case rutile (titanium oxide) being employed as the raw material. This is heated with an excess of carbon in an electric furnace, and nitrogen is forced downward through the charge while in the heated state. A nitride of titanium is produced under these conditions, and ammonia can be obtained from this product, by blowing steam through it, while maintained at a red heat. If desired, the process can be made continuous, and the oxides of calcium, barium or aluminum may be employed in place of rutile.

The writer is unaware whether the Chalmot process has yet emerged from its laboratory stage of development; but if a continuous process of this kind can be operated on a large scale, the question of the production of ammonia from the air would appear to have been solved. The only raw materials of the Chalmot process, apart from the air, are an inexpensive oxide, which can be used indefinitely, and coke, so that the cost of production should be low.

The further experimental trials of the two processes named above will therefore be followed with considerable interest by all chemists and electrochemists engaged in the study of methods for the fixation of the nitrogen of the air.

Carbon Disulphide and Carbon Tetrachloride.

The writer referred to the Taylor process for production of carbon disulphide in the first series of these notes (see ELECTRICAL REVIEW, March 7, 1903), and made some comments in that note, upon the future of this electrical process. Since that date, little fresh information has been published concerning the progress of this new electrochemical industry. Mr. Taylor read a paper upon his process at the Berlin Chemical Congress in June, 1903, but practically nothing new was contained in this publication. The process is, however, believed to be still operating with success at Penn Yan, N. Y., and it is now announced that the well-known Griesheim Elektron Company (the pioneer firm in the electrolytic alkali industry), is about to erect a carbon disulphide plant at its Bitterfeld works. The fact that this firm is about to adopt the electrical process for manufacturing carbon disulphide, signifies that the advantages claimed for it over the older process are real. It was pointed out in the earlier note that the success of processes in which electricity is used as a heating agent depends largely upon a very low generating cost. The Bitterfeld works of the Elektron Company is run by steam power, a very cheap form of brown coal or lignite being employed as fuel; and it is probable that at Bitterfeld the cost of the kilowatt-hour is little in excess of that by the water power generating plant at Penn Yan.

Another carbon compound, namely, carbon tetrachloride, is also being produced on an industrial scale in electrochemical works in France and Switzerland. In this case the electric current is only used indirectly in the manufacture, the chlorine used for decomposing the hydrocarbon being obtained by electrolysis of brine.

This application of portion of the chlorine obtained from the cells in electrolytic alkali works is due to the low price which has been obtained for bleaching powder in Europe during 1903; and now that the arrangement between the various producers has been revived (see ELECTRICAL REVIEW of January 23, 1904), it is possible that less chlorine will be devoted to this new subsidiary manufacture. The works at Moutiers, in France, where the Outhenin-Chalandre diaphragm process is operated, have been producing carbon tetrachloride in this manner during 1903; and the two works carrying on the same process at Chevres, in Switzerland, and at Bussi, in Italy, are understood to have been using portion of their chlorine in the same way. The market for carbon tetrachloride is, however, limited, and the manufacture is unlikely to increase to any great extent.

Artificial Diamonds.

Since Moissan published his researches upon the crystalline form of carbon, some years ago (a summary of the results obtained by Moissan in his experiments was printed in the ELECTRICAL REVIEW of June 27, 1903), little new information has been given to the world on this subject. Moissan succeeded in producing carbon in crystalline form in these experiments, and in fact produced true diamonds in his laboratory; but these were so minute that a lens was required to distinguish them, and his attempts to obtain larger crystals were unsuccessful. This failure seems to have deterred other chemists and metallurgists from attacking the same problem, but recently Gellendien has contributed to one of the scientific societies of Germany a paper describing further researches on this subject by Ludwig.

The principle employed by Ludwig in his experiments was similar to that of Moissan, namely, to bring great pressure to bear upon the carbon at the moment of its passage from the liquid into the solid state; but instead of operating upon carbon dissolved in iron, Ludwig used carbon alone in his experiments. A bomb was employed into which carbon electrodes were sealed. Hydrogen was used to produce the pressure within the bomb, since this gas is inert as regards carbon at high temperatures; and pressures of 1,200 to 3,000 atmospheres were employed. The electric arc was utilized for obtaining the requisite heat; and it was observed that at a certain temperature and pressure the carbon electrodes became non-conducting. This phenomenon was assumed to be due to the passage of the carbon into the crystalline form; but when the apparatus was cooled and the confined gas allowed to escape, only a few very minute semi-transparent particles of carbon could be found in the mass. Sudden cooling, by squirting water into the apparatus, gave a larger yield of these minute crystals; but in neither case was the quantity obtained of any commercial value.

The result of Ludwig's experiments thus confirms Moissan's theory that high temperature, great pressure and sudden cooling have produced the diamonds found in the earth's crust; but it would appear that these forces have acted on too great a scale for the chemist to be able to reproduce them, and obtain large diamonds in the laboratory or works. However, some day the electrometallurgist may discover a practicable method of solving the problem; and the manufacture of artificial gems may, in consequence, be transferred from Paris to Niagara, and crystalline carbon be substituted for "paste."

CARE AND MAINTENANCE OF STORAGE BATTERIES—IV.

BY EDWARD LYNDON.

REVERSAL OF CELLS.

If in a battery one or more cells are in a low state of charge as compared with the remainder of the battery, such condition obtaining in the case of a partial short-circuit or local action, these cells on discharge will give up their entire capacity in a comparatively short time, and with the continuation of discharge the terminal electromotive force of such cells becomes lower and lower until the zero point is reached, and at this point the discharge current flow from the remainder of the battery is in such a direction as to reverse the low cells.

Since all the cells are connected in series, the current on discharge enters by the negative and leaves by the positive plate, each pair of plates adding its voltage. If the voltage of a cell be reduced to zero and current still continues to flow through it from the remaining cells, the current entering the negative electrode will change the lead sulphate on this plate to lead peroxide, and current leaving *via* the positive plate will convert the sulphate at this point to sponge lead, reversing the cell.

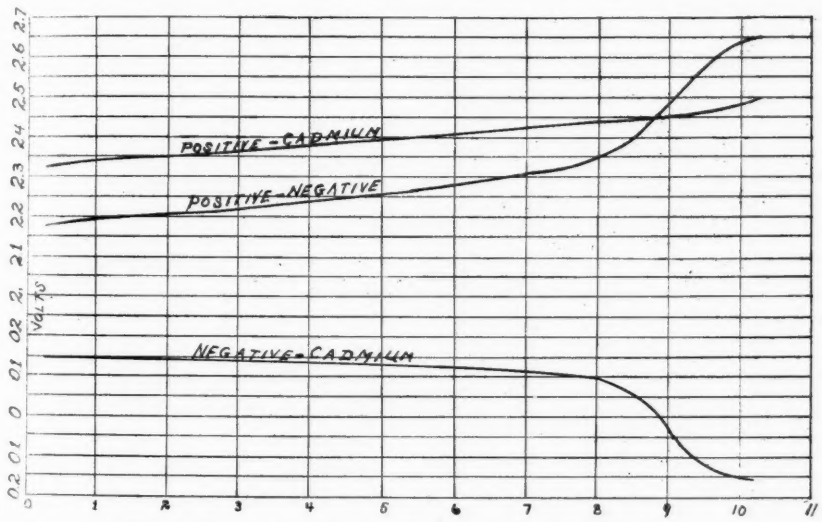


FIG. 3.—CURVES OF VOLTAGE CHANGES IN CADMIUM READINGS.

A reversed cell should be given the same treatment as if it were nothing more than a severe case of sulphating. As soon as such a cell is detected it should be cut out of the discharging circuit. A cell in this condition requires prompt attention in order that no serious damage may result.

LOSS OF CAPACITY.

After a battery has been some time in service it will be found that its capacity decreases. This decrease is continuous and does not, in itself, indicate that the battery has been improperly handled, as diminution in capacity is, to a limited extent, one of the natural properties and corresponds to depreciation in other forms of electrical apparatus. This decrease occurs in both plates, the relative rate of decrease however is greater in the negative than in the positive, for the reason that there is no formation of new sponge lead by the reactions on this plate during charge and discharge and any loss of active material from any cause will decrease the capacity of the negative proportionately, and these plates lose capacity continuously from the beginning of service to the end of their usefulness. It, however, takes place at a very slow rate.

In the case of the positive plate, new active material is continually being formed from the pure base lead in the body of the plate by the action of the charging current and, to a certain extent, the life of Plante positive plates is dependent upon the amount of pure lead in the structure of the plate that can be converted into lead peroxide.

On account of the more rapid decrease in capacity in the negative than in the positive, it is usual in the manufacture of plates to provide some excess capacity in the negative. It is evident that if new peroxide could be formed with sufficient rapidity to counteract the losses in the positive plate that the capacity of such a plate would remain unchanged until all the available pure lead in the plate had been converted into peroxide. This continued formation of the positive applies only to plates of the Plante type in which the active agent is formed electrochemically directly from the pure lead. In the case of Faure or pasted type positive, there is never any further formation, and a plate of this type is subject to continual losses as with the negative. Another cause of capacity loss is local action, which has already been discussed. While the area attacked by local action may be small in each case, yet if the process be continued for any length of time the result will be more or less clogging of the pores of the active material with small isolated patches of sulphate, decreasing the ability of the electrolyte to circulate freely into the active mass and also reducing the amount of useful active material.

Sulphatation to an excessive degree, either by continual under-charge or over-discharge, will cause growths and studding of the active masses and naturally the capacity decreases as the amount of active material becomes less.

With Plante, or electrochemically formed negatives, it is quite possible when these plates have lost capacity to reform them and prolong their life; this, however, should always be done by the manufacturer. Rejuvenation, or restoring of capacity to a limited extent, can be given to some forms of chloride negatives.

The remedy for loss of capacity, other than that which normally takes place, lies in the form of preventive measures—such as keeping the battery free from all substances which may cause local action and working the battery within its normal limits in order to keep down excessive sulphate and consequent loss of active material by blistering and studding.

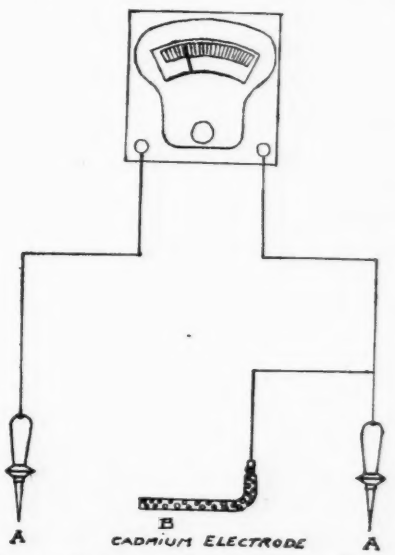


FIG. 4.—VOLTMETER CONNECTIONS FOR TAKING CADMIUM READINGS.

VOLTAGE VARIATION.

If at any period of charge or discharge one or more cells show a voltage which is appreciably different from that of the

other cells, it may be assumed that such cell or cells are not in proper condition. If the voltage be in excess of that of the normal cells in the battery, it will be found that the density of the electrolyte has been greatly increased, giving a consequent rise of potential. The remedy is, obviously, to reduce the density of the acid in the cell showing the high voltage. Excessively high acid densities augment the formation of sulphate and greatly increase local action, hence the advisability of preventing the density from becoming too great.

In the case, however, of a sulphated cell the acid density will be lower and the voltage higher than normal cells on the passage of charging current. In nearly every case it will be found that when a cell shows appreciable difference in voltage from other cells its density will be lower, showing overdischarge, loss of capacity, local action or sulphatation, the last being the result of any of the first three causes. At times it may be that the effects mentioned have taken place at only one of the electrodes, that is, the positive plate may be in good condition while the negative is not.

Voltmeter readings taken on the positive or negative plates with some neutral metal, such as cadmium, is a good indication of the relative state of charge of the plates under test. Such readings are of special value in the case of the negatives, as this plate is far more sensitive to the effects of local action, loss of active material, etc., than the positive. Since the output of any cell is limited by the capacity of the plates which have the lowest capacity, it is important to know that both are in proper condition before the beginning of discharge. The voltage across the cell terminals is not an indication that both plates are fully charged.

Taking cadmium readings consists of observing the difference of potential between a piece of cadmium immersed in the electrolyte and the positive or negative electrodes. The difference of potential between the negative electrode and cadmium being small, some error of observation is likely to occur unless this reading is obtained by means of a milli-voltmeter, and since such an instrument is rarely available for battery work some other method is generally used to get this potential. The voltmeter usually furnished with a battery installation has a scale ranging from zero to three volts and this instrument must serve for all cell-testing purposes.

A piece of cadmium immersed in the electrolyte of a discharged cell and with normal discharge current flowing will be positive to both the sponge lead and peroxide plates, that is, the voltmeter needle will move in the same direction whether the reading lies between the cadmium and the positive or between the cadmium and the negative, the throw of the needle in the former case merely being greater than in the latter. Beginning charge at this point, however, the relation of the immersed cadmium to the sponge lead or negative plate changes as the charge proceeds, the change being that while the cadmium is positive to the negative plate at the end of discharge it becomes negative to this electrode at the end of charge, thus the potential difference between the negative electrode and cadmium begins decreasing with commencement of charge, passes through zero and then becomes negative to the negative electrode with the continuation of the charging current; but from the cadmium to the positive still remains positive. These changes are clearly shown in Fig. 3.

The potential between the cadmium and negative electrode of a cell on discharge will be found to vary from 0.19 to 0.27 volt, depending upon the type and construction of the plates; 0.27 volt being rather too large, 0.20 to 0.25 volt being more nearly good practice for terminal electromotive forces at end of discharge of 1.8 volts per cell.

As charge is continued the potential between the cadmium and the positive electrode increases.

If readings on both positive and negative to cadmium be made, it follows that when readings are in opposite directions the electromotive force of the cell will be given by the addition of the two values, and when the readings are in the same direction the cell electromotive force will be given by their difference. Taking both positive and negative cadmium readings requires manipulation of the voltmeter connections, and there is some liability of error in reading the small deflection from the negative cadmium, so it is usual to take only the cell electromotive force and the potential difference between the positive and the cadmium, the negative reading can be found directly from these two.

Fig. 4 shows the voltmeter connections for taking the readings in this manner, AA are the ordinary prods or stickers connected directly to the voltmeter for taking the voltage in the usual manner and 3 is the cadmium test piece. The method of taking the readings consists of taking the electromotive force by sticking the two prods AA into the terminals of the cell, keeping the cadmium test piece clear of the electrolyte or cell connections; after the electromotive force has been noted remove the prod on the negative terminal and immerse the cadmium test piece, thus getting the potential between it and the positive electrode. From these the negative readings may be computed as previously explained. In taking these readings the cadmium must not come in contact with the plates. A small round bar of cadmium turned up on one end, so that this end will project above the surface of the electrolyte and the whole covered with a perforated rubber tube, is preferable to a flat sheet of cadmium, as it is possible with the covered bar to lay it across the tops of a number of plates in one cell and so get the average condition of each set of plates, while a flat sheet of cadmium designed to go between a pair of plates gives, to a certain extent, the condition of this particular positive and negative. If such a sheet be used differences will be found to exist in the same cells if the sheet be moved to different pairs of plates.

The potential between the cadmium and the negative at the end of discharge should be from 0.19 to 0.25 volt, and the potential between the positive and the cadmium should be from 1.99 to 2.05 volts. At the end of charge the potential between the positive and the cadmium should be from 2.41 to 2.36 volts, while the corresponding potential at the negative should be from 0.22 to 0.26 volt.

In taking such readings with a cadmium electrode considerable care should be exercised, and it is hardly advisable to take such records oftener than once each month, provided all cells are working normally.

The cadmium test piece should be properly aged by letting it rest in the electrolyte for a short time before using, it should never be scraped so that a bright surface is exposed as cadmium will readily oxidize, and there is a difference of potential between cadmium and cadmium oxide that will introduce error in the records.

Electrical Machinery for Spain.

The annual report of U. S. Consul Lay, at Barcelona, Spain, contains a discussion of American trade in Spain, giving reasons why it is not larger. One reason is said to be the method of payment. The Spanish merchants are not accustomed to pay for goods until they see and inspect them, while the American merchant demands cash payment. Many American manufacturers are bound by agreements with European distributing houses, and can not, therefore, sell direct to Spain. Among the long list of goods that the consul believes might be exported to Spain with advantage are dynamos, electrical supplies, cranes, electrical conduits, engines of all descriptions, and motors of all kinds.

A FEW EXPERIMENTS WITH HOLTZ MACHINES[1]

BY SAMUEL SHELDON.

The experiments mentioned in this paper were performed with the aid of two Holtz machines. The first was a standard Waite and Bartlett machine having ten rotating and five stationary plates. The second machine was made by the Galvano-Faradic Company, having eight revolving and four stationary plates.

Efficiency—The efficiency of No. 1 machine and the location of losses were determined in the following manner:

The machine was rotated by means of a belt-connected separately excited electric motor.

Variation of the speed of the motor was produced by varying the voltage impressed upon its armature.

The power imparted to the armature was measured by means of a voltmeter connected between the armature terminals and an ammeter connected in series with it.

The speed of the motor and that of the Holtz machine were measured with a tachometer.

The speed of the Holtz machine was maintained throughout the test at 315 revolutions per minute.

The power lost in the motor was determined, by running with the belt off, to be seventy-six watts.

The power consumed by the tachometer was found to be but 0.42 watt, or a negligible quantity.

The total power consumed, when running the Holtz machine without excitation, was 105 watts.

By subtracting the loss in the motor and neglecting the losses in the tachometer and belt, the loss in the machine due to friction was twenty-nine watts.

After exciting the machine the total power consumption, when the discharge knobs were in contact, was 184 watts, there being no useful output.

The extra loss due to excitation is therefore 79 watts. This will be referred to under the head of internal resistance.

The electrical output when the machine was giving a continuous discharge was equal to the product of the current in amperes by the voltage between discharge points. No. 1 machine was of sufficient size to give a continuous discharge or current between needle points opposed to each other and separated by any distance up to six inches. If this distance were exceeded, the discharge became disruptive and the current, which is pulsating in character, must have been of very high frequency.

This conclusion is drawn from the following observed facts:

A Weston 150-volt voltmeter of 18,566 ohms resistance was inserted (and used as an ammeter) between a discharge needle point and one of the discharge rods of the machine, as at A in Fig. 1.

The connections were supplied with

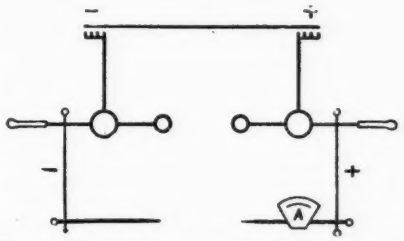


FIG. 1.—EXPERIMENTS WITH HOLTZ MACHINES.

spherical ends. The needles and holders were suspended by silk threads from grooved blocks, which could be slid upon a wooden rod mounted above the machine terminals.

When the needle points were within six inches of each other the ammeter needle was quiet and indicated the passage of a current equal to $\frac{1}{18566}$ of an ampere to each unit deflection on the scale.

If the distance between the points exceeded six inches, then there was also sparking between the metal parts inside the ammeter, occasioned by voltages which the writer is unable to account for, except upon the theory that they were due to high-frequency changes of current encountering the inductance of the ammeter coil.

In spite of this change in the character of the discharge, from a continuous one of less than six inches to a disruptive one of

NEEDLE-GAP	POWER SUPPLIED TO DRIVING MOTOR				USEFUL OUTPUT OF HOLTZ MACHINE			EFFICIENCY
INCHES	VOLTS	AMPERES	TOTAL WATTS	NET WATTS	VOLTS	AMPERES	WATTS	PER CENT
0	82·0	2·00	184	108	11·1	·009597	·1066	0·0
6	96·0	2·10	202	126	7·1,200·0	·000482	34·0	27·1
12	102·0	2·45	250	174	122,000·0	·000315	39·0	22·2
18	101·5	2·50	256	180	188,000·0	·000194	35·0	19·5

FIG. 2.—RESULTS OF EXPERIMENTS.

six inches or more, readings of that portion of the total output current from the Holtz machine, which traversed the needle-gap circuit and passed through the coil of the ammeter, and simultaneous readings of ammeter and voltmeter input at the driving motor, were made for needle-point gaps up to eighteen inches. The actual current output of the Holtz machine at these gap-distances of six inches and above is greater than that indicated by the ammeter readings, because of leakages between the opposite sides of the machine, and around the ammeter coils as above detailed.

The voltage of the discharge for a given gap-distance was taken from the curve of the relations between voltage and needle-point gap-distances in air as given in the standardization report of the American Institute of Electrical Engineers (Transactions, vol. xix, 1902, p. 1091).

The available or useful output of the machine is therefore approximately equal to the product of the voltage corresponding to the gap-distance into the current in amperes, as found by dividing the ammeter reading by the constant 18,566.

The following table, Fig. 2, gives the results obtained; and it should be noted that it shows that when the needle points were brought in contact with each other, and the ammeter coils constituted the only resistance in the external circuit, the voltage output was observed to be 11.1 volts.

Leakage and Internal Resistances—According to the usual and generally accepted theory of the operation of the Holtz machine, it is not a direct generator of electromotive force, but is a gatherer of electrical charges or electrical quantities, which, in flowing to the various parts of the machine and connected circuits, produce in them differences of potential dependent upon their electrostatic capacities. With an external circuit from comb to comb offering a path of finite, constant mean resistance for the expenditure of these differences of potential, the mean electromotive force should be proportionate to the speed of rotation.

Hence the machine, after being fully excited, should produce electricity at a mean rate dependent upon and directly proportional to its speed.

Hence further, if operated with its discharge knobs in contact or with a voltmeter connected between them, thus constituting a circuit of constant resistance, the voltmeter, serving in this case as an ammeter, should show a mean current directly proportional to the speed. This is in accord with the following results of experiment:

Speed in R. P. M.	Current in Amperes.
195	.000366
230	.000440
250	.000476
280	.000527
325	.000610
340	.000648
355	.000678
380	.000733
400	.000759

These results are shown graphically in Fig. 3.

[1] Abridged report presented to the American Electro-therapeutic Association.

While the discharge knobs are in contact there is very little difference of potential between the various parts in the main circuit of the machine included between the collecting combs. As the knobs are separated more and more the discharge becomes disruptive, and potential differences are set up, fluctuating from zero to that voltage which is necessary to break down the dielectric between the knobs.

When the potential differences are large there are evidently many paths of current leakage. The number of paths and the amount of leakage current increase with a rise of potential difference. Probably each of these paths acts as though it consisted of high resistances R in series with dielectric gaps G, as in Fig. 4.

Now this path does not conduct electricity until the potential difference between the combs or prime conductors + and — becomes sufficient to discharge through the gap. If the supply of electricity to this path is sufficiently great, that is to say, if the potential difference between + and — is maintained, or does not fall too low, the current will continue to flow, and will depend in magnitude upon the potential difference, and upon the value of the high resistance, plus the resistance of the broken-down gap.

The value of the equivalent resistance of all leakage paths combined in parallel for a given distance between discharge knobs can be found in the following manner:

Run the machine at such a speed that there occurs no discharge between the knobs and so that if the knobs were brought slightly nearer to each other a discharge will take place.

Under these circumstances all the current that the machine produces escapes through the leakage paths and at a voltage corresponding to the breakdown voltage between the knobs. Calling this voltage V, and the current which the machine produces as this speed I, the value of which is determined by measuring the amperage with the discharge knobs in contact, then the equivalent resistance R of the leakage paths is

$$R = \frac{V}{I}.$$

In machine No. 2 with a knob-gap of eight and three-quarter inches, which was found by a parallel needle-gap of sixty inches to correspond to an exterpolated voltage of 530,000, the speed was such as to yield a current of 0.000162 ampere. This gives the value of the combined leakage resistances as 3,270 megohms.

If it be assumed that there is also an internal resistance in a Holtz machine, which corresponds to the internal resistance of a storage cell or a dynamo, then this resistance may be considered to be located between the collecting combs, by the way of the air-gaps between the combs and revolving plates, and the plates themselves; the air-gaps as a whole and the plates as a whole being connected in series, and in series with the main circuit. Certainly this portion of the circuit is associated with a loss and its magnitude, as a resistance, can be determined.

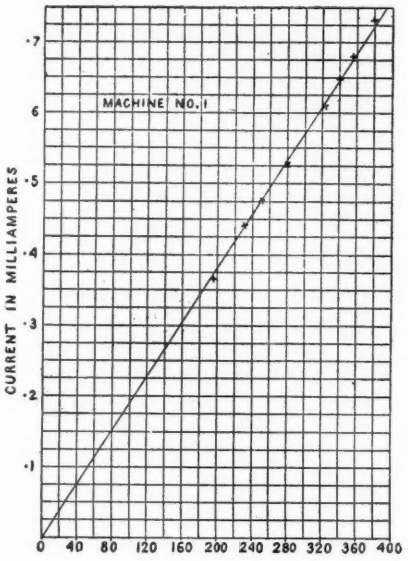


FIG. 3.—GRAPHIC REPRESENTATION OF CURRENT IN AMPERES AND SPEED.

In No. 1 machine, under the head of efficiency, it was shown that this loss was seventy-nine watts, it being assumed that there is no loss due to dielectric hysteresis. The short-circuit current at this time was 0.000597 ampere. Since the loss in watts is equal to the product of the resistance and the square of the current, the resistance

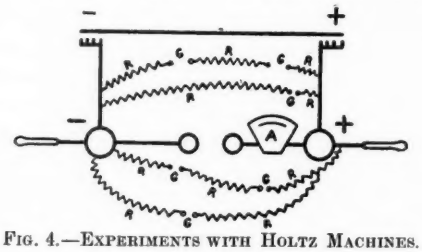


FIG. 4.—EXPERIMENTS WITH HOLTZ MACHINES.

$$R = \frac{P}{I^2} = \frac{79}{(0.000597)^2} = 220 \text{ megohms.}$$

Disregarding this internal resistance and considering the circuit as supplied with constant current at the collecting combs, the arrangement can be represented diagrammatically, as in Fig. 5.

In which

I = current, in amperes, of constant value flowing from the plates to the combs on the positive side of the machine, and from the combs to the plates on the negative side, and through the external circuit.

R = resistance, in ohms, equivalent to the combined resistance of all the leakage paths external to the plates and combs.

C = capacity, in farads, of a condenser having a capacity equal to that between the discharge knobs of the machine.

E_t = potential difference, in volts, between the discharge knobs at time t.

Q_t = quantity of electricity, in coulombs, bound up in the condenser C at time t.

i = leakage current flowing through the leakage resistance R at time t.

i' = current flowing into the condenser C at time t.

And $$Q_t = CE_t = \int_0^t i' \, dt, \qquad (1)$$

from which $$E_t = \frac{\int_0^t i' \, dt}{C}. \qquad (2)$$

But $$i = \frac{E_t}{R} = \frac{\int_0^t i' \, dt}{CR}, \qquad (3)$$

and since

$$I = i' + i, \quad I = i' + \frac{1}{CR}\int_0^t i' \, dt. \qquad (4)$$

Differentiating equation (4) with respect to i', we have

$$o = d\,i' + \frac{1}{CR} i' \, dt,$$

from which $$\frac{d\,i'}{i'} = -\frac{1}{CR} dt,$$

or $$\log_e i' = -\frac{t}{CR} + \text{constant}.$$

Since for $t = o$; $i' = I$, we have for the value of the constant, $\log_e I$, and the final expression for the last equation becomes

$$\log_e i' = -\frac{t}{CR} + \log_e I, \qquad (5)$$

from which $$\frac{i'}{I} = e^{-\frac{t}{CR}},$$

or $$i' = I e^{-\frac{t}{CR}}. \qquad (6)$$

The current-time curve for the current i', which flows into the condenser C, is, therefore, of the form shown in Fig. 8.

If there be no leakage, however, in which case $R = \infty$, then the current i' is constant and equal to I, the total current delivered by the plates to the combs.

If there be no leakage, and therefore the total current I flows into the condenser, it is evident that the potential difference between the knobs at time t will be represented by the equation.

$$E_t = \frac{I\,t}{C}. \qquad (7)$$

With leakage present the value of E_t is obtained by substituting, in equation (3), the value for the condenser current i' given by equation (6), and is

$$E_t = \frac{1}{C}\int_0^t I\, e^{-\frac{t}{CR}} d\,t,$$

or $$E_t = R\,I\,(1 - e^{-\frac{t}{CR}}) \qquad (8)$$

The time curves of potential difference between the knobs are of the form shown in Fig. 6, that for no leakage being, as the character of equation (7) indicates, a straight line.

In the equation

$$E_t = \frac{1}{C}\int_0^t I\, e^{-\frac{t}{CR}} d\,t,$$

if the upper integral limit be taken as the time elapsing between sparks, then t is equal to the reciprocal of the number of sparks per second, a large number of which per second can be accurately counted after a little practice by use of some scheme of rythmic accentuation. E_t then becomes equal to the voltage necessary to break down the gap and can be found by the equivalent parallel needle-gap. The supply current I at the appropriate speed can be found by the voltmeter. There remains but C and R as unknown quantities.

The capacity of the machine may be increased and rendered negligible by the addition of sufficient known capacity. The capacity C of the formula then becomes known, and the average value of R can then be calculated.

Probably of more interest is the use of this formula for the comparison of capacities of small magnitudes, such as are used in wireless telegraphy. No. 1 machine was called for and returned before some experiments along this line had been completed.

Some of the peculiarities of the results summarized in the table, Fig. 3, can now be more clearly understood. As the proportion between observed current and leakage varies widely with variations of potential difference, it is easy to account for the fact that a rise of watts input at the driving motor, amounting to forty per cent (from 126 to 174) yielded a rise of watts output of only fourteen per cent (from thirty-four to thirty-nine); also for the fact that a further rise of watts input accompanying the increase of gap-distance from twelve to eighteen inches, and of voltage from 122,000 to 180,000, amounted to only three per cent (from 174 to 180) and resulted in a fall of watts output from thirty-nine to thirty-five (ten per cent) because of increase of leakage both as to its total amount and its ratio to total current generated.

Between the extremes of spark discharge (six inches and eighteen inches), at which distances the output in watts was substantially the same, the input rose nearly fifty per cent, all of which increase disappeared as leakage in the use of the eighteen-inch gap, causing the efficiency to fall from 27.1 per cent to 19.5 per cent.

Different Currents Produced—An effort

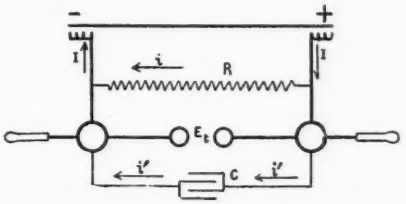


FIG. 5.—DIAGRAMMATIC ARRANGEMENT OF APPARATUS.

was made to obtain information of some of the characteristics of the currents which are yielded by the Holtz machine under different conditions. Three different arrangements of the machine are employed. In the first the machine is used without any discontinuity of conduction in the circuit. In the second, condensers were introduced between the terminals from which current was drawn and the discharge knobs, and in the third, a shunt circuit consisting of two condensers and an inductance was connected across the machine terminals, and currents were drawn from the ends of the inductance. Current drawn from the machine by the first arrangement discolored chemically prepared paper. In the second arrangement there was no discoloration, and with the third, but a slight change in color.

The general proposition which appears to be established by the trials thus far made, can be expressed as follows:

At a constant speed the Holtz machine

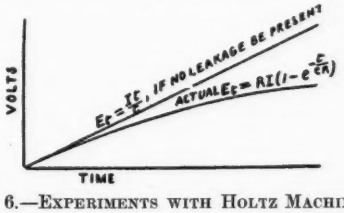


FIG. 6.—EXPERIMENTS WITH HOLTZ MACHINES.

generates a current of constant amperage, irrespective of the distance apart of discharge points or knobs. And the reason why the ammeter did not indicate a constant current flow during the experiments described, with the discharge points at different distances apart, was because an increasing percentage of the current leaked around instead of passing through the ammeter due to the increasing potential difference as the points were drawn farther apart.

New York Section of the American Electrochemical Society.

The first meeting of the New York section of the American Electrochemical Society was held on January 26 in the hall of the Chemists' Club, New York city. Some sixty members were present. Professor C. A. Doremus delivered the introductory address, in which he explained the reasons which had led to the formation of the section. A paper by Professor J. W. Richards, the president of the society, dealt with a review of the commercial systems of the electrolysis of water for producing hydrogen and oxygen. He distinguished three different classes of systems, according to the nature of the diaphragm, which serves to keep the hydrogen away from the oxygen. In the first class of cell non-conducting porous diaphragms are used (Schmidt cell); in the second, solid partial partitions of a non-conducting material (Schoop cell); in the third, partial metallic partitions (Schuckert cell). The paper was concluded by some notes on the cost of the process and on the different applications of electrolytic hydrogen and oxygen.

The second paper was read by Mr. C. J. Reed, on the thermochemistry of electrolytic dissociation, and was an attack on the paper of Professor Richards, presented at the Niagara Falls meeting. In the discussion which followed, Dr. Richards maintained that his position was correct, while Mr. Reed contradicted.

Mr. A. J. Rossi then lectured on the manufacture of ferro-alloys in the electric furnace. He gave a review of the experiments which he has made for several years in Niagara Falls and described the use of carbon and aluminum as reducing agents. He uses aluminum in form of baffles, ingots or scrap in an electric furnace. When the current is turned on the aluminum melts quickly, and in this molten bath he then introduces the metallic oxides to be reduced. Mr. Rossi exhibited a very interesting collection of various ferro-metals produced by him in the electric furnace.

Mr. I. J. Moltkehansen presented a brief note on a "strange observation." In electrolyzing a silver nitrate solution with two platinum wires as electrodes, he obtained two apparently similar deposits at both anode and cathode. Mr. Reed suggested that the anodic deposit might have been silver peroxide.

The by-laws of the section were then adopted and the meeting adjourned. The intention is to hold another meeting in about two or three months.

CENTRAL STATION HEATING.[1]

BY W. H. SCHOTT.

In the past few months numerous papers have been read before various electrical associations and engineering societies on the subject of central station heating.

It is a well-known fact that heat can be delivered from a central point to almost any reasonable distance with very small loss, utilizing either water or steam as a circulating medium, but the question to be decided upon when a central plant is considered, is: Which shall we use, water or steam?

Hot-water heating is in operation in a great many cities; some using a single-pipe closed circuit system, others a two-pipe static head system, and others a two-pipe balanced column system. The single-pipe system being adapted only where there is a limited territory to serve; but where the district to be served is extended over large areas, then in that case a two-pipe system becomes necessary in order to give the system the necessary amount of flexibility required and to furnish a positive circulation. Where the district to be served is compact, with large buildings ranging in height from six to sixteen stories, the situation then becomes a steam heating situation; the steam being supplied at low pressure, being taken either from engines or being furnished direct from boilers.

Heating plants, utilizing either water or steam, are found to be a better investment where exhaust steam is utilized in furnishing the heat, or furnishing at least a part of it.

Where exhaust steam exists and it is desirable to use it, it can be used more economically in a hot-water system than in a steam system, due to the fact that it may be used at atmospheric pressure and even at a pressure represented by a twenty-inch vacuum during the milder periods, the circulation being made positive by using a pump of some pattern as the circulating medium, the power required to operate this circulating medium being governed by the character of pump used and the head which it must work against.

In a well designed water system there is only required from ten to thirty pounds pressure to overcome the pressure due to circulation and friction of mains, the power utilized by the circulation being absorbed in the circulating water so that it is not lost.

With a steam system, sufficient pressure must be maintained upon the mains to overcome the friction in the street work and to furnish the necessary circulation to the surface which is to be heated, this pressure ranging from two to twenty pounds and even higher, but normally at from five to ten pounds pressure.

When the establishment of a central plant is undertaken it should be taken up with the same degree of intelligence as that of any other enterprise, as it is not reasonable to assume that managers and engineers, inexperienced in this work, can secure sufficient knowledge of the business by a casual observation to warrant their passing on a situation as to whether or not it will pay to establish a plant of the above described character.

It is a fact that a central plant, when installed, in order to make it a paying proposition, must have all its detail considered, and not the mere placing of equipment, pipes, mains, etc., to complete the circulation.

In taking up the question of the central station heating plant, the territory to be heated should be carefully examined by some one familiar with its needs and then a plant designed that will give an economical operation, together with a superior service, to meet the needs as found.

If the territory, after having had the physical examination made, proves that it will be a paying investment providing the plant is properly installed and managed, then the next feature that needs serious consideration is the franchise question.

A franchise granted by a municipality empowering a corporation or others to use its streets, alleys and public places for the purposes of laying down and maintaining pipes, does not place on the municipality any extraordinary burden. In fact, it is an assistance to the municipality, due to the fact that after the street is put back in place properly there is nothing about it to wear out the pavement or cut up the streets in any manner or sense, any more than the placing in the streets of a sewer.

On the other hand, due to the centralizing of all the fuel burning for a large number of buildings to one point, this point usually being located upon a railroad in the manufacturing part of the city, relieves the street of the usual traffic caused by delivering the fuel to the buildings so heated.

A company undertaking the establishment of a heating plant in a city, instead of being burdened by severe restrictions, should have the support of the city officials and public at large, and a liberal franchise should be granted so that a plant can be established that will not only be a credit to the city in which it is installed, but also a paying investment.

Many franchises granted in the past and accepted by companies undertaking to operate under them, should never have been accepted, due to the fact that the rates were entirely too low, or the company failed to have the proper control of its business, resulting in the disaster of the company undertaking to operate under the same.

After having secured the proper franchise, then the plant to be installed should be of the best design possible to attain, no matter whether it be a steam or water proposition.

High-grade power-house equipment in any power plant has proven conclusively that it pays only to use the best that can be obtained in the market and should be ample evidence that the same would apply to a heating system.

The street work should be installed in the best possible manner known, great care being taken to see that the mains have ample capacity; the expansion to be taken care of in a proper manner so as not to throw undue strain on any fitting in the system; that the insulation should be of the best so as to reduce the street losses to a minimum; the pipe lines should be properly underdrained so as to eliminate the possibility of water logging, and, if a steam system, great care should be taken in the maintaining of grades so that the mains will be properly drained.

In the piping and connecting of buildings to the system great care should be taken in the equipment, as no system will operate economically and satisfactorily unless its pipes are properly proportioned so as to circulate with practically no friction, and its radiation is so proportioned so as to properly heat in the coldest weather, or, namely, twenty degrees below zero in this climate.

All piping in buildings, no matter whether it be a steam or water system, should be properly covered.

The radiating surface set should be of ample surface to heat the space to be heated without calling upon the risers and mains in the building to assist, due to the fact that in the milder periods, when the minimum amount of heat is required, while the circulation to the radiator may be closed off, the heat would still dissipate itself through the mains and risers, if not covered, and whenever the temperature of the space so heated rises above the standard, it then becomes wasted, due to the fact that doors and windows are

[1] A paper read before the twelfth annual meeting of the Northwestern Electrical Association, Milwaukee, Wis., January 20, 21, 22.

opened and the same is permitted to pass to the outside atmosphere.

The covering of the pipes and mains and placing of sufficient radiation to maintain the temperature desired, increases the cost of the installation to the consumer, but as this installation is of a permanent nature, the small percentage of increase due to its requirements is not excessive and should be insisted upon.

More plants throughout the country are not operating satisfactorily to their owners on account of the buildings which they are heating not being properly radiated than from any other cause known.

The radiation required for a building should be based upon the minimum temperature contended with, or twenty degrees below zero. If sufficient radiation is set to maintain standard temperature at twenty degrees below zero, a company is only called upon to operate forty per cent of its maximum of the radiation so set as an average during the entire heating season.

On account of the requirements varying as they do, it becomes (in order to make the system as economical as possible) an absolute necessity to adopt some form of regulation, or otherwise a large amount of heat is wasted.

In a water system it is much easier to regulate the temperatures without using automatic regulation than it is in a steam system, due to the fact that the temperature of the water may be varied to suit the outside conditions, so that in the milder periods the surface can not throw off as many heat units as otherwise, due to their lower temperatures, but from tests made, a regulated system will save to the central station forty per cent of its fuel requirements, and in making this forty per cent saving in fuel, it must necessarily mean also that forty per cent more business can be carried on a given plant with regulation than it can without. This statement is correct during the average of the season, but due to the fact that the requirements must be based upon twenty degrees below zero, the plant must operate under one of two conditions, namely:

The plant having ample capacity to handle the connected load at twenty degrees below zero, or

It having its capacity to handle this load economically during the average of the season and then depending on its overload capacity to take care of it during the coldest periods, which would correspond to the peak in a lighting station during the holiday period.

While the above may be true it is poor engineering to undertake to carry out a station upon these lines, as the plant should have ample capacity to meet its requirements at twenty below zero, due to the fact that enough can be saved in operation during its extremely cold period to offset any charges chargeable against the property, due to its larger capacity, in addition to ensuring to the consumer an absolute service.

Many of the plants installed in the past do not have the capacity claimed for them.

In a well designed water system, during the average temperature of the heating season, six to eight pounds of water per square foot of radiation per hour is ample to furnish all the heat required by the surface so supplied, but when the temperature is twenty degrees below zero, it then requires twelve to eighteen pounds of water per square foot per hour, and the plant must have capacity to deliver a sufficient amount of water during these periods to furnish the heat to the surface to heat the space as required.

The same conditions practically apply to a steam plant as to a water plant.

In tests made recently I find a wider range in a steam plant than in a water plant. Comparing the tests taken in a building where the radiation set was up to the requirements, against a building where the radiation was set on a fifty-two per cent basis, I found that a change of thirty-four per cent in outside temperature varied the condensation in the building where radiation was properly set 13.72 per cent, while in the building underset, the same change in outside temperature varied the condensation 24.24 per cent.

In comparing the condensation in buildings where the radiation is properly set against the condensation in buildings underset, I find it to be as follows:

First—Building properly set:

Wind velocity 10.3 miles per hour.

Average outside temperature thirty degrees.

Average condensation per square foot per hour 0.158 pound per hour.

Second—Building set fifty-two per cent.

Wind velocity 10.3 miles per hour.

Average outside temperature thirty degrees.

Average condensation per square foot per hour 0.365 pound per hour, or on account of this building being underset, twenty-two per cent more condensation took place than would have taken place if the radiation had been set to requirements.

From the above you will readily see that the proper installation of the radiation is a very important factor. In both of the above buildings the steam supply to the buildings was controlled by regulation.

On the question of how to charge for heating a given space, various methods are used, some basing their charges upon a cubical contents basis, varying the charges on account of the construction of the building. Others charge on a basis of so much per square foot of heating surface. Others charge upon a basis (and this applies to steam only) of the number of pounds of steam condensed.

Certainly the cubical contents charge basis is entirely wrong. A building, due to its construction and exposures, may vary from two to eight or ten changes of air per hour. These changes govern the amount of heat required to heat the space in question. Necessarily to heat properly the radiation must be based upon the maximum number of changes of air that will take place per hour, and as the number of square feet or radiation set governs the operating expenses of a central station, it must in that case be the basis of charge, either from a square foot basis or a meter basis.

The objections usually raised to a meter basis are the same objections that have been raised by consumers of electric light companies; namely, that when the current which they have used to supply their light and power is furnished through a meter, they are limited in service. In other words, they will take care of their light and power and use it only as their requirements call for it, while if they have a flat rate they pay no attention to the same, thereby very materially increasing the cost of operation to the central station, in addition to requiring a much larger amount of capacity to take care of the connected load than they would otherwise. This applies to the meter basis of measurement.

The consumer will call upon the station for his maximum demand, which is represented by the connected amount of radiation when we have our minimum outside temperatures, but during the milder periods will have a large amount of the radiation cut out of service, first due to the fact that they do not need it; secondly due to the fact that they are trying to save in heating bills and are very liable to cut them down to a point where it is below their actual requirements, resulting in a dissatisfied customer.

With the radiation furnished on a square foot basis and without regulation, a price that would justify the company in operating the same without any restrictions would seem prohibitive, but the application of regulation to the same acts

practically in the same capacity as the meter does to the electric light plant, in not permitting the building to be overheated, yet furnishing to the consumer the necessary heat to maintain seventy or seventy-two degrees, the temperature usually agreed upon, and with the consumers securing their heat upon this basis, they are usually much better satisfied than upon a meter basis and the income to the company per foot per season should average higher than where the same is on a meter basis.

Probably the ideal method of furnishing heat to the consumers from the station standpoint would be to furnish the same through a meter, and at the same time give the consumer automatic regulation. The regulator would prevent the building being overheated, in addition to giving an even temperature line, and at the same time the company would be paid for all heat so supplied.

To give you an idea of what is actually being done in practice on the question of regulation, I refer you to a chart which I have prepared. This was taken and is the average of several charts for a period of one week. You will note from the chart that the range is within two degrees. These charts were taken from a building having a west and south exposure, front of glass, sides about two-thirds brick and one-third glass.

No manipulation of valves is made in the building at any time, but the circulation of the building is automatically controlled by a regulator at all times. From this chart you will see that there is no overheating or underheating, but a constant temperature is maintained at all times. The regulator (and this applies to both steam and water systems) closes off the circulation from ten to seventy per cent of the time in each twenty-four hours, this depending entirely on the outside temperature, and as an average during a heating season, will keep the circulation closed off over forty per cent of the time.

From this you will see the extreme importance of automatic regulation to a central station, regardless of any statements made against its use, it becomes an important factor in the successful operation of a heating station.

To any one considering the installation of a heating plant, all of the features and facts herein referred to should be very carefully considered, as they are extremely important in making the enterprise the success that it should be.

Central electric lighting stations should find heating plants, when properly installed, valuable additions to their properties. If lighting and power companies are in position to furnish heat in addition to their light and power, they can eliminate a large percentage of the isolated plants with which they have always to contend.

The average large building is compelled, on account of its proper heating, to maintain a boiler plant seven or eight months in each year. As a usual proposition the lighting and power required in this same building during this time will have a period of twelve to sixteen hours per day, furnishing sufficient exhaust steam to heat the same so that the expense of operating the combined plant is only slightly increased during this period and on account of it becoming necessary to operate a plant seven or eight months a year; numerous cases exist where they will install a plant and operate throughout the entire year.

If these same buildings are in position to secure light, heat and power from a central plant, a majority of the isolated plants throughout the country can be secured by the central stations, and plants now in operation in them can be closed down, and in new buildings being erected no plants at all will be installed, as the experience has been that plants of this description are expensive to maintain when all charges are being considered, but buildings have been driven to the installation of them due to the fact of being compelled to furnish heat.

In addition to a heating plant enabling a central lighting company to control this class of business, it also enables it to fortify its business against municipal ownership by having a satisfied community, in addition to guarding against encroachment of opposition companies, as a lighting company operating a heating plant in connection with it in our smaller cities is certainly in a much stronger position than one without it, due to the fact of its being able to furnish all classes of service required, so that in considering the establishment of a plant of this character there should be considered the advantages to be gained by the operation of a consolidated property of this kind, and due credit should be given the heating department for the assistance it renders the lighting department in securing profitable lighting and power business, that a company otherwise could not obtain.

The Council of the British Institution of Civil Engineers have nominated their president, Sir William Henry White, K. C. B., to fill the place of the late Sir Frederick Bramwell as one of the representatives of that institution on the Engineering Standards Committee.

COIL WINDINGS FOR ELECTRICAL PURPOSES.[1]

BY RICHARD VARLEY AND CHARLES R. UNDERHILL.

The electromagnet as a temporary power transformer has long been in general use for various purposes and has now reached a stage where it can be standardized for performing a certain amount of work through various distances. As there is very little data on the subject and the rquirements are so exacting, the practical method of obtaining data is to construct electromagnets of different forms and sizes and make actual tests, and having once found the pull which may be produced through various distances with different magnetizing forces, it is then comparatively easy to determine what size of wire should be used for any given voltage to produce the desired results.

To begin with, the first data usually given is the tractive force, or the amount of pull required. The next is the distance through which this force must act. This gives the total amount of work in foot-pounds. The time-factor does not enter into the work so much in a case of this kind, but the time that the current is to be left on the winding does determine the size of the winding, particularly the outside diameter, as the winding must have sufficient superficial area to radiate heat rapidly enough to prevent the winding itself from becoming overheated. If the area is not sufficiently great, the heat will not have sufficient outlet, so to speak, and therefore the winding will get extremely hot, which heating not only raises the resistance of the winding, thereby decreasing the ampere-turns for a constant voltage, but is also liable to damage the insulation, thus causing a short-circuit, and, in consequence, a complete burning out of the coil.

In studying the many phases of electromagnets, very interesting points are noticed. For instance, for long ranges the pull will vary almost in direct ratio to the ampere-turns, while for short ranges—that is, where there is a short gap in the circuit—the proportionate pull will be much greater for low magnetizing forces than for high magnetizing forces. The reason for this is obvious. In the case of a long range, the iron will not become sufficiently saturated to increase the total reluctance of the magnetic circuit, as the reluctance of the air-gap is at least ninety per cent of the total reluctance. In the case of the short air-gap, however, and particularly if the sec-

[1] Paper read before the twelfth annual meeting of the Northwestern Electrical Association, Milwaukee, Wis., January 20, 21 and 22.

tional area is great, the reluctance of the gap may not exceed, or in some cases may be less than the reluctance of the iron portion of the magnetic circuit, therefore it is very difficult to make any set rule for determining the pull.

Again, there has been very little data published regarding the coil and plunger type of magnet, or solenoid. General magnetization curves have been shown, but no particular working data given, therefore the manufacturer of electromagnets has to make a great deal of original research in order to be able to make estimates on electromagnets specified under varying conditions. It has been found that by making different sized magnets of various types, that a general curve may be drawn by reference to which the proper dimensions may be found for any pull through any range desired.

The data required from customers ordering is as follows:

The pull, whether uniform or accelerating.

The distance through which the pull must act.

The time the current is to be on the magnet, and

The length of time between the contacts operating the magnet.

It should also be specified whether the magnet is to be in a vertical or lateral position unless the weight of the armature is to be counterbalanced by a weight or spring. When this is not specified, it is customary for the manufacturer to make the pull of the magnet great enough to include the weight of the armature. It is important to know the length of time the current will be on the winding in order to make the radiating surface sufficiently great, and also to know the length of time between the contacts, as the magnet will cool during that time, and so that this may be deducted from the heating.

Again, there is little data given which enables the designer to actually determine just how much a magnet will heat with a given voltage, or current, and this again has to be practically determined from actual tests. By these means a standard line of electromagnets and solenoids has been designed, standard patterns made, etc., which enables the customer to obtain exactly what he wants at market prices, just as he purchases a dynamo or motor.

There is no good reason why the customer should not be able to obtain an electromagnet to perform any reasonable operation, and this on the open market, just as he would obtain a dynamo or motor.

As an example: let us assume that an electromagnet is required which will pull twenty-five pounds through a range of ten inches.

Now, since the field of the solenoid is nearly uniform throughout its entire length, the solenoid immediately suggests itself for this purpose.

But here the designer lacks data on the relation between the ampere-turns in the winding and the necessary diameter of the plunger in order to fulfil the specifications. The practical way out of this difficulty is to make a test. By selecting several lengths of solenoids with different diameters, and by testing these solenoids with various sizes of plungers, excellent data is obtained which helps the designer to determine the proper size of solenoid and plunger for any specific purpose.

It is obvious that an ironclad solenoid is stronger than the simple type of solenoid, as the iron completes the magnetic circuit. But here again the designer lacks data, and therefore tests must be made before the actual design can be completed.

Again, the plunger electromagnet is much stronger than the simple or ironclad solenoid, for short distances, as it has the combined functions of the ironclad solenoid and the electromagnet, and data has to be obtained for this. So it is for all the different types of electromagnets. True, we have excellent data for electromagnets with closed magnetic circuits, but it is a rather difficult undertaking to accurately calculate the action of an electromagnet when its range of action is comparatively great.

The pull does not vary by any known law, such as the square of the distance, or the cube, for that matter, but the pull is much greater when the air-gap is small than when the air-gap is great, although in the latter case the pull is more uniform for a given range.

Where the air-gap is small, the iron portion of the magnetic circuit may also be short, as less electrical energy is necessary to produce sufficient magnetomotive force to send the required amount of flux across the gap. In all cases the magnetic circuit should be as short and as large as possible in cross-section, but for long air-gaps much more room is required for the winding necessary to force the lines through the large air-gap, *i. e.*, a winding of higher pressure is required and where the reluctance of the air-gap is great, the reluctance of the longer iron portion of the magnetic circuit will be negligible by comparison with the reluctance of the gap. The time that the current is to be in the winding also determines the size of the winding, as a winding which is to be in circuit only momentarily will not require as much radiating surface, and therefore a much larger wire may also be used, thereby reducing the size of the winding for the same ampere-turns.

To the casual observer, the winding of an electromagnet is the least important of that indispensable detail of so many electrical devices. The magnet circuit is carefully considered, as it should be of course, but the winding is briefly referred to in terms of ampere-turns. This is correct, so far as it goes, but how about the economy of that winding? How shall the winding itself be so constructed that the maximum of magnetic energy in ampere-turns may be obtained with the minimum amount of electrical energy?

The ampere-turns are, of course, dependent upon two things only; namely, the resistance of the average of all the turns in the winding, and the electromotive force applied to the winding.

This rule is based upon the following reasoning: assume a single layer of insulated wire wound upon a core of any given diameter. Now assume but one turn of wire with, say, one volt pressure on that turn. If the resistance per turn of wire is 0.01 ohm, the resultant current would be 100 amperes, therefore for one turn of wire there will be 100 ampere-turns. Now assume two turns of wire with the same total pressure, *i. e.*, one volt. The resistance will then be 0.02 ohm and the current fifty amperes. Then fifty amperes and two turns equal 100 ampere-turns as before. This rule holds the same for any number of turns, only in the practical condition the average diameter of all the turns is taken.

As the current strength for a constant resistance is dependent upon the voltage, in the case just considered the ampere-turns for ten volts would be ten times the ampere-turns per volt, or 1,000 ampere-turns. Therefore it will be seen that the ampere-turns, for any specific case in which the voltage and mean diameter of the winding are given, depend entirely upon the resistance of the average turn regardless of any number of turns in the winding.

The economy of the winding for any specified number of ampere-turns depends entirely upon the number of turns in the winding, as the greater the number of turns for the same mean diameter, the greater will be the resistance, and conse-

quently the less will be the current for the same ampere-turns and voltage.

The meaning of this is, that less electrical energy is required to maintain a given magnetizing force in a coil with many turns of a given size of conductor, than with a few turns of the same conductor.

The ideal condition would require a wire whose cross-section should be square or rectangular, and the insulation should be vanishingly thin, that is, the convolutions should be insulated from one another, without any space being occupied by the insulation. The practical conditions, however, are far from being ideal, not only with respect to the exceedingly thin insulation, but also on account of the infeasibility of using wire of square or rectangular cross-section, owing to the perversity of the square wire in endeavoring to rest upon its corners in the winding, instead of on its flat sides, as is assumed in the ideal case, and while the rectangular wire or ribbon answers very well for heavy work, it does not give satisfactory results with wires finer than No. 14 on account of the greater amount of insulation required to cover it for equal cross-sections as compared with round wire and for this reason best results are at the present time obtained with round wire.

The ordinary method of insulating is to wrap cotton or silk about the wire. For all practical conditions cotton is quite as good for insulating as silk, but owing to the greater thickness of the cotton, the silk-covered wire winding is more economical as to operation, although a trifle more expensive in first cost.

Let us compare the various weights of copper in the ideal case with the weights of copper in the windings with silk and cotton-covered wire.

In the ideal case the winding volume would be entirely filled with copper, while in the practical cases the volume occupied by the insulation as well as the volume lost due to the interstices between the turns of round insulated wire must be deducted from the total winding volume to give the volume of the copper.

For this purpose let us consider a winding volume of one cubic inch. For the ideal condition, the weight of copper would be 0.03 pound, while for a No. 30 B. & S. wire insulated with silk to a two mil increase, the weight of the copper would be but 0.175 pound, and for a cotton-insulated wire of the same diameter, the increase in diameter, due to the cotton, being four mils, the weight of the copper in the winding would be but 0.129 pound.

It is sometimes desirable to use an insulating material which will not burn when the winding becomes very hot, and asbestos-covered wire is used to some extent, especially in arc lamps where the temperature of the controlling magnets is influenced by the heat from the arc, but while this insulation is not inflammable and does not char or crumble, it is so thick that only a small portion of the available winding volume is filled with copper, and for this reason the asbestos-insulated wire is not economical, as compared with cotton-covered wire.

In the calculation of the proper wire to be used in a given bobbin for any specific purpose, there are two factors which must always be determined. One is the resistance factor, and the other, the space factor. These two factors may be combined and called the combined space and resistance factor, and expressed in terms of "ohms per cubic inch." Therefore, if we know the cubical contents of our bobbin, and have previously calculated a table of "ohms per cubic inch" for the various sizes of insulated wire, we may quickly determine the proper size of wire for our purpose.

Let us consider a round winding: since the winding on a bobbin of circular section is really a hollow cylinder:

The volume will be $\pi L \left(\frac{D^2 - d^2}{4} \right)$ cubic inches.

Where D = outside diameter of winding
d = inner " " "
L = length " " "

Now let us consider the section and length of insulated wire which is to comprise the winding. First let us get our resistance coefficients.

It has been found by experiment that a commercial soft copper wire 0.001 inch in diameter has a resistance at sixty-eight degrees Fahrenheit of 10.3541 ohms. Now, since for the same length the resistance of conductor decreases in direct ratio to the sectional area of the conductor, the resistance will vary with the square of the diameter of the wire. Therefore, denoting the diameter of the wire by $\triangle$, the ohms per foot for any diameter of copper wire will be $\frac{0.0000103541}{\triangle^2}$, or the ohms per inch — $\frac{0.00000086284}{\triangle^2}$

Now it is obvious that if we know the length of a given wire that will just fill the bobbin in question, we may quickly find the resistance by multiplying the length of the wire by the resistance per unit length. But here we must consider the sectional area of the wire and insulation. For wires of a smaller diameter than No. 20 B. & S. the cotton makes the total diameter 0.004 of an inch greater than the diameter of the wire. This is generally referred to as a four-mil increase.

When the wire is wound into the bobbin, the turns of one layer cross the turns of adjacent layers at an angle which is dependent upon the diameter of the wire and the diameter of the turn. Therefore at a certain point in each turn the corresponding turn of the adjacent layer will be centrally over this turn, but 180 degrees around where the wires cross one another the wires will imbed slightly.

The gain due to imbedding is approximately 7.3 per cent, but since this gain in space is about equally offset by the spreading of the insulation laterally, due to the vertical tension of the wire during the process of winding, the longitudinal sectional area of the bobbin consumed by each turn of the wire is approximately equal to the square of the diameter of the wire and insulation.

The turns, then, are equal to the longitudinal cross-sectional area of the winding divided by the square of the diameter of the wire plus insulation, or $N = \frac{\pi L}{g^2}$

Where
N = total number of turns in the winding
T = thickness of winding
L = length of winding
g = diameter of wire plus insulation

Now the total length of the wire L w in the winding will, of course, be equal to the number of turns multiplied by the average length of all the turns, or

$$L\,w = \frac{\pi\,L\,(D^2 - d^2)}{4\,g^2}$$

Therefore the resistance P of the winding will be

$$P = \frac{0.00000086284\ \pi L\,(D^2 - d^2)}{4\,g^2\,\triangle^2} = \frac{0.0000027107\ L\,(D^2 - d^2)}{4\,g^2\,\triangle^2}$$

To simplify the operation in practice, it is customary to calculate separately the constants for the various sizes of wire, both the resistance and space factors. Since for any given size of insulated wire with given insulation the space and resistance factors may be resolved into the combined space and resistance factor, and in this factor the constant T is incorporated, therefore the resistance P may be found by the simple formula:

$$P = RL \left(\frac{D^2 - d^2}{4} \right)$$

where R equals the combined space and resistance factor.

Space and resistance factors are arranged in the form of tables for reference, therefore only the volume of the bobbin need be found in order to ascertain the resistance which may be contained therein with any size of wire, or the size of wire may be determined which will give the desired resistance for any winding volume. In this latter case, however, the true outer diameter of the winding must be recalculated, as the calculated constants seldom coincide with the tabulated constants, therefore the next smaller size of wire is taken and the true outside diameter of the winding calculated by the formula

$$D = \sqrt{\frac{4\,P}{RL} + d^2}$$

For windings of square or rectangular cross-section special formulæ are required. However, these formulæ only have to be used in determining the average length of all the turns, as the thickness and length are the same as in a winding or circular cross-section.

In order to obtain the theoretical results in practice certain precautions must be taken, for instance, the actual diameter of the insulating sleeve must be taken, and also the exact diameter of the wire and the thickness of the insulation. A change of one ten-thousandth of an inch in the diameter of a No. 35 wire will change its resistance about six per cent for equal lengths of wire, therefore caution must be taken to be sure that it is not stretched during winding, as the ampere-turns will be materially reduced.

A slight increase in the insulation will also make a marked change in the amount of wire in a winding.

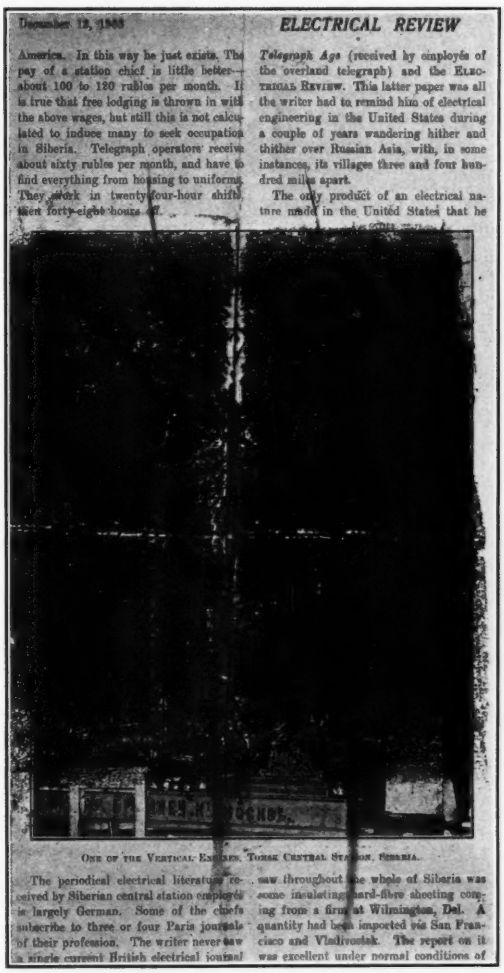
Also, in calculating the weight of insulated wire the specific gravities of the wire and insulation must be known.

Improvements in the Paris Underground Railway.

It is reported that the Paris Metropolitan Railway has decided to abandon the use of cables carrying large currents through the train, and will equip its cars with the Westinghouse electropneumatic turret-type control apparatus, to replace the present system. The feature of the electropneumatic control system is that compressed air is employed for actuating the controllers on all motor cars, and control is effected by small currents and wires throughout the train, at a pressure of fourteen volts.

The Export and Domestic Issue of the Electrical Review in Siberia.

The accompanying illustration is an interesting exhibit of the Russian press censor's work. This illustration is made from a page of the ELECTRICAL REVIEW of December 12, which has been returned to the editorial office by a correspondent in Tomsk, Siberia, under date of December 31. Our correspondent is concerned as to what there was of a treasonable or seditious nature, reflecting on the Russian administration, in the illustration which has been thus obliterated. The illustration was nothing but an innocent reproduction of one of the vertical engines at the Tomsk central station.



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America. In this way he just exists. The pay of a station chief is little better—about 100 to 120 rubles per month. It is true that free lodging is thrown in with the above wages, but still this is not calculated to induce many to seek occupation in Siberia. Telegraph operators receive about sixty rubles per month, and have to find everything from housing to uniforms. They work in twenty-four-hour shifts, often forty-eight hours on.

Telegraph Age (received by employés of the overland telegraph) and the ELECTRICAL REVIEW. This latter paper was all the writer had to remind him of electrical engineering in the United States during a couple of years wandering hither and thither over Russian Asia, with, in some instances, its villages three and four hundred miles apart.

The only product of an electrical nature made in the United States that he

ONE OF THE VERTICAL ENGINES, TOMSK CENTRAL STATION, SIBERIA.

The periodical electrical literature received by Siberian central station employés is largely German. Some of the chiefs subscribe to three or four Paris journals of their profession. The writer never saw a single current British electrical journal

saw throughout the whole of Siberia was some insulating hard-fibre sheeting coming from a firm at Wilmington, Del. A quantity had been imported via San Francisco and Vladivostok. The report on it was excellent under normal conditions of

The lot of the newspaper man in Russia is decidedly hard, and although this work is one of the most pleasant undertakings in any other country on the globe, it is not so in Russia, where the government spends more money on its press censors than on its schools. It is understood that last year eighty-three papers were suspended for various periods, and twenty-six were forbidden to accept all advertisements, while 259 editors were told they could have a short vacation in Siberia if they continued their methods of reviving interest in various public meetings.

The illustration which was offensive to the eye of the Russian press censor appeared in an article entitled "Electricity in Siberia," written by an American traveler who had spent considerable time in that country, and who was conversant with the conditions there. Why the text was left intact and the most innocent illustration obliterated is past finding out.

It is not very often that the work of the press censor in Russia comes to light in this way. The recipient of a paper, a portion of which has been blacked out as in this instance, is generally fearful of calling attention to it, and does so at considerable risk; but it is a well-known fact that very few publications go through without having some portion of the material expunged in just such a ridiculous fashion. This matter must not be regarded as merely comical, because it seriously militates against the acceptance of good literature in Russiadom, in that the Siberian is very properly afraid to continue buying a journal which has come under the ban of the censor.

Electrical Notes from Europe.

By Our Special Correspondent.

THE city of Zurich is considering a project for installing a large hydraulic plant in the vicinity. The question has been under consideration for several years past, and some definite measures will no doubt be taken in the near future. The waters of the Sihl will be utilized, at a point near the Etzel, which is a mountain lying on the south bank of the lake of Zurich. The Sihl is a stream which has a rapid fall and is already used to give hydraulic power. It will be possible to obtain as high as 60,000 horse-power under the proposed conditions. The current is to be utilized for supplying light and power to the city of Zurich and also the surrounding region, in which there are several large towns. The municipality will no doubt set apart the sum of $5,000 in order to have the matter examined by a technical committee. The project which has been submitted by the Oerlikon Company, of Zurich, provides for plants of different capacities, varying from 60,000 horse-power down to 13,000. The total cost of construction, including the hydraulic and electric plant, the transmission lines and the transformer stations, supposing the turbines to deliver 60,000 horse-power during eleven hours per day, figures $5,134,000. The other projects give the figures for plants down to 13,000 horse-power, which will cost $3,120,000. Out of the 60,000 horse-power which was originally proposed, the city of Zurich will no doubt take 25,000 horse-power for the city lighting and power circuits, leaving the remainder for tramways and electrolytic plants, as well as for the circuits in the surrounding region. The towns of St. Gall and Schwytz are associated with Zurich in this enterprise, and it will no doubt be of great benefit to the region.

A new primary battery has been recently invented by two Hungarian engineers, Csanyi and Barczay, which is an improved form of Bunsen cell. It is claimed to be greatly superior to the latter. The essential feature of the battery is the use of a mercury salt for the electrolyte. This has been proposed before, but the inventors have secured a greatly increased effect by adding cyanide of potassium and alcohol to the mercury solution. Carbon plates twenty-four centimetres high, seven wide and one thick are placed in one compartment of a cell, and separated from a similar zinc plate two millimetres thick by a porous diaphragm. The carbon is placed in concentrated nitric acid. For the zinc, the electrolyte is a solution of mercury, to which is added cyanide of potassium and alcohol. To test the superiority of the new battery it was run against a similar cell, using only nitrate of mercury for the zinc. The results of the different tests showed a considerable difference in favor of the new cell. This will be noticed by the following figures: After a thirty minutes' run on a resistance of 0.1 ohm, the ordinary cell showed 0.550 volt and 5.05 amperes, while the new cell gave 1.425 volt and 13.20 amperes.

A very practical application of wireless telegraphy has been made by the Italian Legation at Pekin. It has installed a station at its headquarters which allows it to exchange messages with the Italian war vessels which lie in the harbors of Taku or Tientsin. This gives it a direct connection with the fleet without needing to use the Chinese overland lines. The value of such a system is at once apparent and it would be of the greatest service in case of war. The Legation can also telegraph to the war vessels which are cruising off the northern coast of China. At the time of starting the station, messages were exchanged between the Legation and Vice-Admiral Mirabello, on board the battleship Victor Pisani, located in the Gulf of Petchili.

The new German cable from Emden to the Azores, which was finished during the latter part of October, forms part of the German-American cable which will ultimately reach New York. The first cable from Emden to New York was laid in 1900, but as this has been found insufficient, it was decided to double it by a new line running parallel with the first. The cable is being laid by a German company, and it is proposed to finish the whole by the end of this year. The section which is now completed from Emden to Horta, in the Azores, has a total length of 1,950 nautical miles. This is the first cable of such importance to be constructed and laid by a German firm. The work was carried out by the Nordenheim Company, which has a large cable factory. The first section starting from Emden measures 800 nautical miles, and in this part the cable contains 226.8 kilogrammes of copper and 131.5 of gutta-percha per mile. This section has a central wire of 2.73 millimetres diameter, which forms a core for the rest of the cable, consisting of twelve wires of 0.910 millimetre. The cable which is thus formed has its spaces filled up with Chatterton compound. The average resistance of the cable measures 2.42 ohms per nautical mile at twenty-four degrees centigrade. The gutta-percha covering is applied in three layers which are placed alternately with three layers of Chatterton compound. The cable has a high insulation resistance, measuring 400 megohms per mile and its capacity is only 0.435 microfarad per mile. The 1,150-mile section which completes the line to the Azores has a central wire of 2.43 millimetres, surrounded by twelve wires of 0.817. The cable contains 181.44 kilogrammes of copper and 127 of gutta-percha per mile. The resistance is 3.025 ohms and capacity 0.405 microfarad per mile. The first section of the Emden-Azores cable is laid on a comparatively shallow bottom, and is provided with a protecting covering of brass strip, with an outer wrapping of galvanized iron wire. The whole is covered with a bituminous tape.

The resistance of selenium has been found to be diminished not only by light but by X-rays and those given off by radium. A. B. Griffiths now finds that it is also lowered by exposure to alcoholic solutions of certain vegetable pigments. An exposure of fifteen minutes at a distance of five centimetres gives a marked effect. A solution of the coloring matter of geranium petals caused the resistance to drop from 462,000 ohms to 320,000. The verbena pigment gave a fall from 340,000 ohms to 290,000, and other vegetable pigments produced like results. It is to be inferred from these results that the pigments give off rays analogous to the others which affect selenium.

Among the large central stations of Germany may be mentioned that of Charlottenburg, which has grown very rapidly during the last few years. It now has a capacity of 85,000 lamps, and with the extension which is now going on, this figure will soon be increased to 130,000 to supply the growing consumption of current. The station belongs to the municipality, and was installed in 1900 by the Lahmeyer Company. It is used for supplying light and power to the city, and

also furnishes current for the railroad stations belonging to the state. The transmission lines operate at 600 volts for the most part, but the station is also equipped with two-phase lines which work at 3,000 volts. The plant is located on the north bank of the Spree. The boiler-house is equipped with six boilers, each having 300 square metres heating surface. The ash and slag are ground up in motor-driven machines and sold to the trade for making refractory brick and similar objects. The station contains four alternators which deliver 3,200 volts at ninety revolutions per minute. The first three alternators give 143 kilowatts, the second and third, 440 kilowatts each, while the fourth gives 220 kilowatts. The direct-current part of the plant consists of two generators of 440 kilowatts, which operate at 600 volts, with a speed of ninety-four revolutions per minute. These machines are driven by horizontal engines. In one of the groups an alternator and a direct-current machine, each of 440 kilowatts, are connected on the same shaft to a horizontal engine of 500 horse-power. This group is used as a reserve. The fields of the alternators are excited by two rotary converters of seventy-five kilowatts each. The latter machines also serve to light the station and for other local uses. A battery of accumulators is connected in parallel with the rotary converters. It has a capacity of 810 ampere-hours. Two transformers of eighty-five kilowatts supply the rotary converters. They lower the voltage of the alternators from 3,000 to seventy volts. A large storage battery is operated in parallel upon the tramway circuits in order to take up the variations of load. A motor-dynamo group is used for this purpose. The motor is of the non-synchronous type and delivers 100 horse-power, working at 480 revolutions per minute, with a voltage of 3,000. The motor is coupled to a fifty-eight-kilowatt generator, which delivers current at 45 to 165 volts. The high-tension circuits of the station use six double cables, which distribute current to seven feeding points. The secondary circuits throughout the city are supplied from the high-tension circuits by 110 transformers.

Snow caused an accident on the overhead part of the Paris Metropolitan not long ago, which although not of a very serious nature in the present case, might have proved so under other circumstances. The fact that a snowfall is a rare occurrence no doubt accounts for the lack of proper precautions for preventing accidents of this kind, but it is likely that the matter will be looked into so as to provide for the future. Owing to a short-circuit between the third rail and the ground, a number of the insulating blocks which support the rail were burned, and one of the motor-cars caught fire. The accident occurred on the overhead structure which forms part of the new section of the Metropolitan lying in the northern part of the city. It was on this section that the disastrous tunnel fire occurred a few months ago. Owing to a short-circuit between the third rail and the ground, caused by the snow, a fire broke out which burned up twenty of the insulating supports of the rail. These supports are composed of a metallic piece resting on the tie and a second piece which supports the rail. The two are separated by an insulating block of paraffined wood, which has proved very satisfactory in the tunnel sections. The car which was burned did not contain any passengers, which made the accident less serious than it might have been. It occurred early in the morning, and traffic was interrupted on this section during the whole day.

An electric traction line which will prove of great convenience to tourists is the tramway connecting the Resina station of the railroad with the incline which runs up the slope of Vesuvius. Tourists wishing to see the crater have only to take the train from Naples to Resina, which lies on the coast between Portici and Torre del Greco, and then connect with the electric line. This takes them to the first station of the Cook incline, which lies high up on the slope of the mountain. From there the incline brings them to within a short distance of the crater. It has been necessary heretofore to make a long (and expensive) carriage drive from Naples to the incline, or else mount up on horseback from below. The new electric line is to be opened up shortly. It is 4.5 miles long. On the last section which climbs the mountain at a heavy grade, the Strub rack-and-pinion system will be used.

In the report of the Belgian consul to Yokohama are to be found some points relating to the tramway lines in Japan. The city of Tokio is now changing over its lines from animal to electric traction. A long electric road is that which runs between Fujisawa and Kamakura; it has been in operation for six months or more and works very successfully. The trucks of the cars and the electric outfit have been furnished by a German firm, but the car bodies were built in Japan. An electric tramway is soon to be constructed in Osaka. It will be under municipal control. The line is to run from the harbor through the town for a length of three miles or more. An electric road of home construction will be the new line which is to run from Osaka to Kobé. It is in charge of the Hanjin Electric Traction Company. This road will be no less than twenty miles long. It is to be divided into nine sections for the construction work and given to native contractors. It is of interest to note that the metallic part of the roadbed is to be supplied by a home company, the Mitsui Busan Kaiska, which is a large metallurgical establishment devoted to structural ironwork. It is to be remarked in general that electric traction is on the increase in Japan. Home companies seem to control operations almost entirely, and it is only the motors (and in some cases the trucks) and a few other parts which are ordered from foreign countries.

Paris, January 30. C. L. DURAND.

Proposed Electric Railway in Cuba.

Cienfuegos has railway communication with Habana, Matanzas, Cardenas, Sagua la Grande, and Caibarien on the north coast, with Santa Clara in the interior, and thence, since the completion of the new Cuban Central Railroad, with Santiago.

Mr. Max J. Baehr, consul at Cienfuegos, Cuba, writes:

"A project is now under consideration by local and American capitalists for the construction of an electric railway extending from this city into the interior, a distance of thirty miles or more, which would give rapid transit between Cienfuegos and several important villages in the sugar-producing belt, these towns now having very inadequate communication with this port. I am credibly informed that a company has been organized to carry the project into effect, that a charter has been applied for and obtained, and that only a short time will elapse before the beginning of active work on the grading of the road. If this enterprise is carried to fulfilment, as seems reasonably certain, it will not only give employment to a large number of laborers who now find steady work only during the sugar-grinding season, but will contribute in no small degree to the material upbuilding of this section of Cuba.

"For the information of American dealers in electric and railroad supplies, I will state that the name of the company undertaking this work is the Cienfuegos, Palmira & Cruces Electric and Power Company, with headquarters at Cienfuegos."

THE ALTERNATING-CURRENT RAILWAY MOTOR.[1]

(Concluded.)

BY CHARLES P. STEINMETZ.

In the theoretical investigation and practical calculation of the repulsion motor, just as in the polyphase and single-phase induction motor, the transformer feature is made the starting point and the motor considered as a transformer, the secondary of which is standing at a constant angle ω with regard to the primary, so that motion results from the repulsive thrust existing between primary and secondary.

Let in vector denotation:

E_0 = impressed electromotive force used as zero vector e_0;

I = primary current;

I_1 = secondary current reduced to the primary by the ratio of turns (the same as customary in induction motors);

Z = primary exciting impedance; that is, primary induced electromotive force, divided by primary current at open secondary circuit;

Z_0 = primary self-inductive impedance;

Z_1 = secondary self-inductive impedance reduced to the primary circuit;

ω = angle between primary and secondary axis; that is, angle of shift of brushes from the position of complete transformer action;

$a = (N/_0\Lambda)$ = ratio of speed to frequency.

The total magneto-motive force acting upon the primary coil is then: primary current I plus component of secondary current acting in the direction of the primary, or $I_1 \cos \omega$.

Hence,

$$I + I_1 \cos \omega$$

This, then, is the primary exciting current; and the primary induced electromotive force is therefore $(I + I_1 \cos \omega) Z$.

The primary impedance voltage is $I Z_0$.

Hence,

$$e_0 = Z (I + I_1 \cos \omega) + I Z_0.$$

In the secondary circuit an electromotive force is induced by its rotation through the magnetic flux M_1 in quadrature with the secondary axis, which is in phase with this magnetic flux. This magnetic flux M_1 is due to the component of primary current acting in this direction: $I \sin \omega$, since the secondary current exerts no magneto-motive force at right angles to the axis of the secondary coil. The electromotive force induced thereby is in phase with I.

This electromotive force induced by flux M_1 is therefore,

$$E_1 = a\, x\, I \sin \omega \qquad (4)$$

In the secondary, an electromotive force is induced also by the alternation of the magnetic flux M_2 in the axis of the secondary coil.

This magnetic flux is produced by the magneto-motive force of the secondary current I_1 and the component of primary current acting in this direction: $I \cos \omega$, hence, due to

$$I_1 + \cos \omega$$

and the electromotive force induced hereby is

$$E_2 = - Z (I_1 + I \cos \omega)$$

The impedance electromotive force of the secondary circuit is $Z_1 I_1$, and since the secondary is short-circuited, it is

$$Z (I_1 + I \cos \omega) + Z_1 I_1 - a\, x\, I \sin \omega = 0$$

These are the two fundamental equations of the repulsion motor:

Primary circuit:

$$e_0 = Z (I + I_1 \cos \omega) + I Z_0$$

Secondary circuit:

$$0 = - a\, x\, I \sin \omega + Z (I_1 + I \cos \omega) + Z_1 I_1 \qquad (5)$$

Where we assumed the impressed electromotive force e_0 as zero vector.

From the second equation it follows:

$$I_1 = \frac{- I Z \cos \omega - a\, x \sin \omega}{Z + Z_1}$$

Substituting this in the first equation, gives:

Primary current;

$$I = \frac{e_0}{Z} \frac{Z + Z_1}{a\, x \sin \omega \cos \omega + Z \sin^2 \omega + Z_0 + Z_1 + \frac{Z_0 Z_1}{Z}} = e_0 (a_1 + j\, a_2) \qquad (6)$$

Secondary current;

$$I_1 = \frac{e_0}{Z} \frac{Z \cos \omega - a\, x \sin \omega}{a\, x \sin \omega \cos \omega + Z \sin^2 \omega + Z_0 + Z_1 + \frac{Z_0 Z_1}{Z}} = e_0 (b_1 + j\, b_2)$$

Hence,

Power-factor; $$\cos \phi = \frac{a_1}{\sqrt{a_1^2 + a_2^2}}$$

Volt-ampere input; $$Q_0 = e_0 I = e_0^2 \sqrt{a_1^2 + a_2^2}$$

Power input; $$P_0 = /e_0, I/^1 = e_0^2 a_1$$

Power output; $$P = /E_1 I_1/^1 = /a\, x\, I \sin \omega, I_1/^1$$
$$= a\, x \sin \omega / I, I_1/^1$$
$$= a\, x\, e_0^2 \sin \omega (a_1 b_1 + a_2 b_2)$$

Torque; $$T = (P/a) = x \sin \omega / I, I_1/^1 = x\, e_0^2 \sin \omega (a_1 b_1 + a_2 b_2).$$

Efficiency; $$\gamma = \frac{P}{P_0} = \frac{a\, x \sin \omega (a_1 b_1 + a_2 b_2)}{a_1}$$

etc.

Substituting

$Z_0 + Z_1 = Z^1 = r^1 - j\, x^1$ = total internal self-inductive impedance. Neglecting minor terms, it is, approximately:

Primary current;

$$I = \frac{e_0}{(a\, x \sin \omega \cos \omega + r^1) - j\, (x \sin^2 \omega + x^1)} \qquad (7)$$

Secondary current;

$$I_1 = - \frac{e_0 (\cos \omega - j\, a \sin \omega)}{(a\, x \sin \omega \cos \omega + r^1) - j\, (x \sin^2 \omega\, x^1)} \qquad (8)$$

Angle of lag; $$\tan \phi = \frac{x \sin^2 \omega + x^1}{a\, x \sin \omega \cos \omega + r^1} \qquad (9)$$

Torque; $$T = \frac{e_0^2\, x \sin \omega \cos \omega}{(a\, x \sin \omega \cos \omega + r^1)^2 + (x \sin^2 \omega + x^1)^2} \qquad (10)$$

The secondary current leads the primary current by angle

$$\tan x_1 = a \tan \omega$$

The secondary current comes in phase with the primary impressed electromotive force e_0, if

$$\frac{a \sin \omega}{\cos \omega} = \frac{x \sin^2 \omega + x^1}{a\, x \sin \omega \cos \omega + r^1}$$

hence,

$$a = - \frac{r^1}{2\, x \sin \omega \cos \omega} + \sqrt{\frac{x^1}{x \sin^2 \omega} + \frac{(r^1)^2}{4\, x^2 \sin^2 \omega \cos^2 \omega}}$$

[1] A paper presented at the 183d meeting of the American Institute of Electrical Engineers, New York, January 29, 1904.

Above this speed, the secondary current leads the primary impressed electromotive force e_0, hence magnetizes.

At $a = 1$, that is, at synchronism, the secondary current equals the primary current, $I_1 = I$, but leads by the angle of brush-shift ω.

At infinite speed, $a = \infty$.

$$I = 0$$

That is: the primary current decreases with increasing speed, down to zero at infinite speed. (In the ordinary induction motor the current can never fall below a certain minimum value, the exciting current.)

In this case,

$$I_1 = j\,(e_0/x \cos \omega)$$

that is, lags ninety degrees behind the primary impressed electromotive force, hence is ninety degrees ahead of the phase of a transformer secondary current, and supplies the magnetizing current of the magnetic circuit just as a condenser in the secondary circuit of a transformer would do.

At standstill:

$$a = 0;$$

$$I = \frac{e_0}{r^1 - j\,(x \sin^2 \omega + x^1)}$$

$$I_1 = \frac{e_0 \cos \omega}{r^1 - j\,(x \sin^2 \omega + x^1)}$$

$$\tan \phi = \frac{x \sin^2 \omega + x^1}{r^1}$$

$$T = \frac{e_0^2\, x \sin \omega \cos \omega}{(r^1)^2 + (x \sin^2 \omega + x^1)^2}$$

Current and torque are a maximum, the power-factor a minimum at standstill.

Backward rotation:

For negative values of speed a the torque T is still positive, hence opposed to the rotation, and the repulsion motor with reversed brush-angle ω acts as brake.

The primary current,

$$I = \frac{e_0}{(a\, x \sin \omega \cos \omega + r^1) - j\,(x \sin^2 \omega + x^1)}$$

for negative values of speed a becomes wattless, when

$$a\, x \sin \omega \cos \omega + r^1 = 0$$

or

$$a = -\frac{r^1}{x \sin \omega \cos \omega}$$

For higher negative values of a, or if at a speed greater than $a = (r^1/x \sin \omega \cos \omega)$ (a very low speed), the brush-angle ω is reversed, the energy component of the primary current becomes negative; that is, the motor returns power into the line.

Unlike the plain series motor, which can never return power into the line, the repulsion motor when reversed becomes a generator, consumes mechanical power as brake and returns electric power into the line, even at low speeds. Experiment verifies this feature.

DISCUSSION OF THEORY.

In the preceding outline of the theory of the single-phase alternating-current repulsion motor, the impedances Z, Z_0, Z_1, have been assumed as constant.

While this is approximately the case in the ordinary induction motor, it is not the case with the repulsion motor which works over a wide range of magnetic flux densities.

With increasing load and thereby increasing current and decreasing speed, magnetic saturation is approached and causes a decrease of the impedances Z, Z_0, Z_1, which has to be taken into consideration in predetermining the characteristic curves of such a motor. Furthermore, the different component magnetic fluxes are affected differently by saturation. The flux M interlinked with the primary coil is approximately constant and therefore affected by saturation only indirectly, while the flux M_1 at right angles to the line of polarization of the secondary coil is approximately proportional to the load and so reaches saturation at high loads, and the impedances become thereby different in the different directions of the magnetic structure.

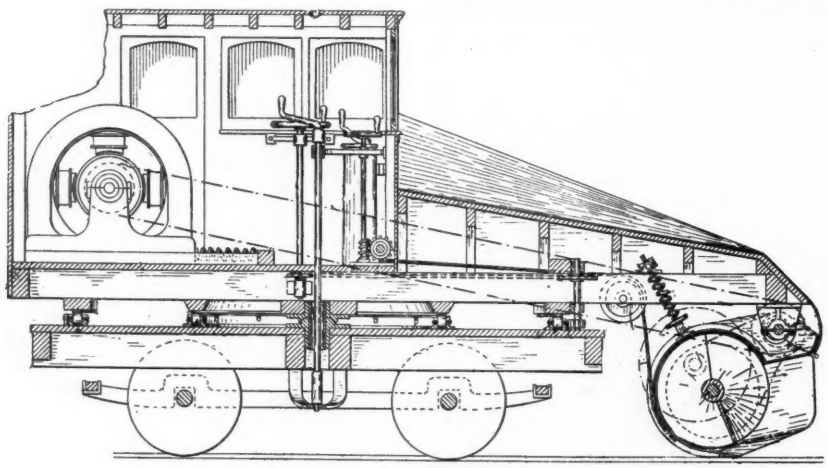
The magneto-motive forces in the preceding have been treated as vector quantities, independent of their distribution around the periphery of the armature. This distribution, however, is different with the different magneto-motive forces. The magneto-motive force causing the effective flux M_1 is due to a zone of the primary winding within the angle $\pm \omega$ from the axis of the secondary coil, hence nearly a concentrated winding, which gives a flat-topped flux distribution, while the flux M_2 in the direction of the axis of the secondary coil is that of a distributed winding or peaked. For the same magneto-motive force the effective flux M_1 is therefore greater than the effective M_2. Taking this into consideration, gives the motor somewhat better characteristics than calculated above. Due to the different wave shapes of the fluxes M_1 and M_2, they are affected differently by saturation. The flat topped flux M_1 reaches saturation at a much higher value, but then over the whole range, while the peaked flux M_2 shows the effect of saturation at a lower value but then gradually, by a rounding off of the peak. In the repulsion motor it is therefore not sufficient merely to consider the resultant magneto-motive forces as vectors but their distribution in the air-gap and the effect of saturation must be taken into consideration in the calculation and design of the motor. An exhaustive investigation hereof has been made by my assistant, Mr. M. Milch, and may be communicated at a later date.

The secondary circuit of the motor has been considered as the seat of two electromotive forces induced respectively by the rotation through flux M_1, and by the alternation of flux M_2. These electromotive forces, however, have no separate existence. At synchronism, for instance, the magnetic field is an approximately uniformly rotating field and therefore no electromotive force is induced in the armature conductors except that required to overcome the resistance. The secondary frequency varies with the load and thereby the secondary self-inductive reactance which we assumed as constant in the preceding discussion. This is best taken into consideration by a theory developed by my former assistant, Mr. S. Sugiyama, of Japan. The primary impressed alternating magneto-motive force of the current I is resolved into two component magneto-motive forces of half intensity, revolving synchronously in opposite directions. If now $a =$ the ratio of speed to synchronism, the two oppositely revolving components of I revolve with regard to the secondary system with the speeds $(1 - a)$ and $(1 + a)$ respectively. The same consideration applies to the secondary magneto-motive force I_1, and in the secondary system we then have induction at two frequencies, $1 - a$ and $1 + a$, of which the former becomes zero at synchronism. That is, at synchronism the secondary current in the armature conductors is of double frequency, similar as in the ordinary single-phase induction motor. At other speeds it is the superposition of two currents of the frequencies $1 - a$ and $a\ 1 +$, respectively. This theory more closely allies the repulsion motor with the ordinary induction motor. Using the same values of secondary impedance, Z_1 for both components, obviously leads to identically the same equations as given in the preceding.

The complete investigation of the repulsion motor must also take into consideration the current flowing in the armature coil during the moment where the coil is short-circuited by the brushes passing from commutator segment to segment. The magneto-motive force of this short-circuit current of commutation is at right angles to the axis of secondary polarization of current I_1, hence has the angle of brush-shaft $-(90 - \omega)$. A corrective term must therefore be applied, taking this phenomenon into consideration, essentially of the character of a repulsion machine with negative or generator brush-angle of $(90 - \omega)$ and very high effective secondary resistance. This term is very small or negligible at speeds up to a point somewhat beyond synchronism but becomes noticeable at speeds considerably above synchronism, due to the decrease of the main current at these speeds.

Electrical Patents.

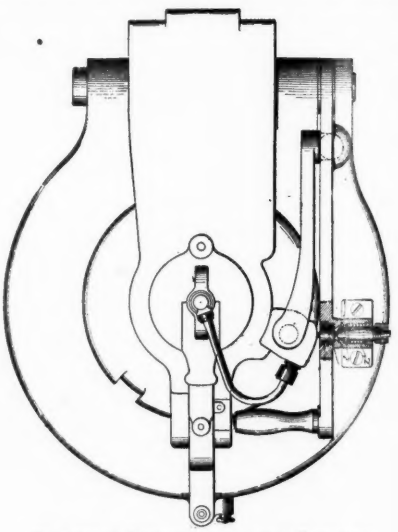
A reversible rotary snow-plow of novel construction has been patented by Mr. Otis Cutting, of Seattle, Wash., who has assigned a one-half interest in the patent to Mr. Maximilian J. O'Donnell, of the same place. In carrying out this invention, a truck and its propelling means are employed, which may be of any usual or suitable construction. Mounted upon the truck-bed is the car body which is provided with an extension, projecting beyond either end of the truck according to the direction in which it is to travel. A stationary or non-rotatable shaft is supported to the body by suitable brackets. A cylindrical casing open at one end is disposed with its axis transversely of the car track when the body is in its operative position and is positioned to the rear of and beneath planes projecting through the axis of the shaft, to which it is hinged by webs or arms. A shaft is journaled in bushings which are fixedly seated upon a shaft. By this mounting means are provided to alter the distance between the axis of oscillation and the axis of the screw-shaft, while the difference between the axes of the driving and driven sprocket-wheels remains constant. The eccentric bushings are adjusted to take up the slack of the chain by partially rotating the shaft and securing it by clamping the brackets thereon. A portion of the peripheral wall of the casing is removed to provide an opening for the intake of the snow which is guided thereto by means of flaring scoop flanges projecting forwardly from the margins of the aperture. The bottom flange which is intended normally to rest upon the upper surface of the track rails so as to clear them of snow, upon coming in contact with any stationary object capable of damaging the casing—as, for instance, the end of a guard rail—the casing and rotary screw therein are moved backwardly and



Reversible Rotary Snow-Plow.

bracket boxes axially of the casing and extends through the closed end thereof. A spiral plate or web of one or more convolutions is integrally connected directly to the shaft or to a hub, which is keyed thereon. A sprocket wheel is fixedly mounted upon this last shaft and is connected by a chain to a wheel loosely mounted upon the stationary shaft, but integrally connected by a sleeve with a pulley. Driving connection is made by a wire rope between this pulley and another pulley upon the shaft of a suitable motor placed within the pilot-house of the car body. Provision is made for regulating the tension of the driving rope and chain by placing the motor upon sliding bearings or runners and interposing a spring between the motor frame and a chock, secured to the car body, and by mounting the fulcrum ends of the casing suspension webs upon eccentrically bored thereby raised, so as to pass freely over the obstruction. A spring is provided for pressing the casing down to its operative position immediately after it has passed over any obstacle upon the track. Mechanism is also provided for swinging the body around or reversing it. The car body is arranged to be rotated upon the truck, and to accomplish this segmental and circular tracks are employed which are carried upon casters or rollers respectively journaled in suitable bearings upon the truck-bed. The rotary motion of the car body is accomplished within the limit of their action by means of a gear pinion and rack, the rack being secured to the truck, while the spindle of the pinion is journaled in suitable bearings, secured to the car body, and is actuated by a chain passed around wheels of the spindle and of a hand-actuated spindle extending upwardly into the pilot-house. After the pinion has traveled beyond the end and out of mesh with the engaged rack the car body can be easily and quickly shoved around by the crew until the pinion is in mesh with the rack at the other end of the truck. A king-pin is included in the mounting of the car body and is made hollow for the passage of the electric supply or controlling wires and a brake staff which is connected in any suitable manner with brake-shoe devices of the truck.

Mr. John F. Meigs, Mr. Sigard A. S. Hammer and Mr. Leighton N. D. Mixsell, of Bethlehem, Pa., are the inventors of an electric firing gear for breech-loading guns, the object of which is to provide a simple and effective arrangement of parts whereby there is provided a safety connection for the firing gear, which will prevent the premature discharge of the gun or a discharge before all the operative

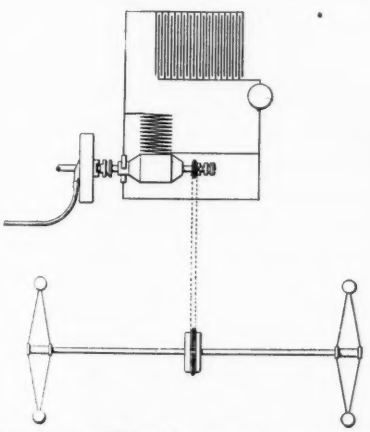


Electric Firing Gear for Breech-Loading Guns.

parts of the breech mechanism and its connections are practically in their normal or loaded position. The patent obtained on this invention has been assigned to the Bethlehem Steel Company, of South Bethlehem, Pa. The invention consists in providing a safety connection for an electric firing gear so arranged that the firing circuit can not be completed until the parts are in the desired position, and in order to obtain the best advantages the parts are so arranged that the circuit is controlled by some one of the parts of the breech block or its operating mechanism, which completes its movement at or about the time the breech mechanism is secured and locked in position, and preferably the circuit is controlled by a part of the operating mechanism which has a relatively large movement compared to the movement of the breech block or plug, and more especially has this relatively large move-

ment just before the breech plug is seated in the breech, so that the ratio of movement between the part of the operating mechanism and the plug is relatively very large at this time. Furthermore, an electric connection with a break is provided which is adapted to be closed by some part of the operating mechanism of the breech block which is not closed until the breech block is practically in position and is then closed by a part of the operating mechanism having a relatively large movement compared to the movement of the breech block, and in this preferred form of construction a double break is provided for closing the break in the firing circuit, and the parts are so arranged and constructed that not only is the break closed, but the parts are locked in position in the act of closing the break.

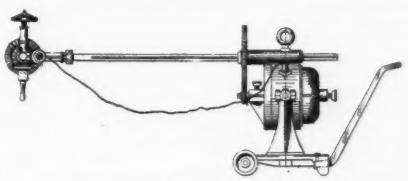
Mr. Thomas A. Edison, of Orange, N. J., is the inventor of an improvement in electrical automobiles, which has for its object to provide an electric automobile in which the driving motor may be conveniently and effectively utilized for the purpose of charging the batteries. The invention consists in providing a small steam or other elastic pressure engine, preferably of



DIAGRAMMATIC VIEW SHOWING ARRANGEMENT OF APPARATUS.

the turbine type, either connected at all times to the armature of the electric motor or adapted to be connected to it through a suitable clutch, so that by reversing the electrical connections or by reversing the rotation of the motor-armature the electric motor will be converted into a generator for charging the batteries. A clutch connection can also be effectively utilized for disconnecting the electric motor from the driving wheels during the charging operation, although it will of course be understood that the driving wheels may be jacked up, so as to be driven during the charging operation. In carrying out the invention, the motor is preferably shunt-wound, and on the armature shaft of said motor is mounted a sprocket wheel which drives the vehicle wheels through a chain. Storage batteries are employed and also a suitable controller either for interposing resistance in the motor-circuit or for effecting variations in the electrical connections between the batteries and the motor for controlling the speed of the motor. A clutch may be used for connecting or disconnecting the sprocket wheel from the armature shaft. A small steam or other fluid pressure engine, preferably of the turbine type, is adapted to be connected to or disconnected from the motor-armature by a clutch. A connection with this engine is made through a hose-section with any suitable source of steam or other pressure.

Mr. George F. Campbell and Mr. Stanley T. Isherwood, of Bootle, near Liverpool, England, are the inventors of a portable electrically driven drilling apparatus, for which they have obtained a patent in this country. In this apparatus a motor is mounted on two horizontal trunnion-bearings carried in a bracket, adapted to pivot relatively to a truck about a vertical axis. The base of the bracket is steadied on the truck by means of a circular race upon which it rides. Where the motor is to be slung the trunnions are carried in an encircling bow and form the horizontal axis, the supporting chain or rope providing for the movement about the vertical axis. In the present form of drill, the speed reduction from the motor shaft to the drill head is effected as follows: on one end of the motor shaft is fixed a pinion which gears into a spur wheel mounted on a hollow shaft, preferably carried on the casing of the motor. A length of shafting keywayed for the greater portion of its length is adapted to move axially through the hollow shaft, the latter being provided with a fixed key which slides in the keyway of the shaft and by means of which the hollow shaft drives the sliding shaft. The drill head comprises the usual drill socket and feeding screw provided with a hand wheel for regulating the feed. A short length of shaft sheathed in a tube forming part of the frame of the head is adapted to form an extension of the first-mentioned shaft, and be secured to it by means of a coupling. The respective ends of the sliding shaft and the long shaft are coned male and female, and the coned end of the sliding shaft is also provided with a feather, the two coned parts being forced into frictional contact and the feather held in its keyway by a nut. Secured to the other end of the shaft is a bevel pinion, gearing into a large bevel wheel which is in turn attached by set screws to one of a pair of mitre wheels, the other being secured to a drill socket spindle. The frame of the head is branched from the tube to form two bearings, carrying two studs which screw into a cross piece and allow of the drill being almost completely rotated about their common axis, a stud also forming a spindle upon which the coupled wheels rotate. The cross piece is made integral with a spindle socket. A set pin engaging in a groove turned into the spindle retains the latter in place. It will thus be seen that the rotation of the motor shaft is conveyed to the drill socket through the pinion and spur wheel, the hollow shaft, sliding shaft and extension shaft, bevel wheels and mitre wheels. The end thrust of the drill spindle is taken on two convex surfaces of hardened steel, on the drilling centre line instead of on a collar, as is usual. The necessary abutment for the feed screw is provided and a controlling switch is mounted on the drill head and connected up to the motor through the leads. This form of apparatus admits of five different motions. The motor as a whole may be rotated on the trunnions about the horizontal axis and on the circular race about the vertical axis. The shaft is capable of sliding axially through the hollow shaft and the drill may be rotated about one axis and partially about the other. The axis about



ELEVATION OF GENERAL ARRANGEMENT OF APPARATUS.

which the motor and the drill head may rotate being in each case in planes at right angles to each other, gives in combination with the sliding motion of the shaft a very considerable range of adjustment.

Annual Meeting of the American Electrochemical Society.

The next annual business meeting of the American Electrochemical Society will be held in Washington, D. C., April 7, 8 and 9, 1904. Full information concerning this meeting, with a programme of papers, will be sent to all members early in March.

Titles of papers for presentation at this meeting will be received by the secretary up to February 25. It is the intention of the publication committee to print for advance distribution all of the papers which reach the secretary in complete form by this date.

Reviews of Current Engineering and Scientific Literature.

The Iroquois Theatre Fire.

This is a complete report by Mr. J. M. T. Stewart of the fire which destroyed the Iroquois Theatre, Chicago, December 30, 1903. The report states that the fire is supposed to have been caused by an open arc lamp used for light effects on the stage. There were eight of these lamps not entirely enclosed. The fire hazard of open arc electric lights, where sparks may fall on inflammable material, is too well known to permit their use under certain conditions, as in dry-goods stores, etc.; but the danger was ignored in equipping the stage of the Iroquois Theatre. The asbestos curtain was inoperative, the probable cause being the proscenium light board hinged on the wall, which is said to have swung out under the north end of the curtain. There was practically no fire protection on the premises, and no fire-alarm apparatus. The electric lights for the auditorium were not under proper control for such emergencies, being dependent upon the stage control for their operation. There was no special illumination of the exits by red lights or other indicators. The superior character of the building construction created over-confidence and a disregard of the inflammable nature of the contents of the fireproof building.—*Abstracted from Insurance Engineering (January), New York.*

Wireless Telephony.

A brief but comprehensive review of the work done toward perfecting the wireless telephone system is here given by Mr. Joseph B. Baker. Taking as an analogy the difference existing between wireless telegraph systems and the ordinary Morse system, he draws the inference that the successful wireless telephone system will be radically different from that used in telephone transmission to-day. He believes that the value of the connecting wire between two stations is being looked upon in a far more scientific spirit by those who wish to see methods of rapid telegraphy replace the older methods, and it follows that, in abandoning the pair of wires necessary to commercial telephonic transmission to-day, advantages that look at present like absolute requisites of commercial service will have to be abandoned and replaced by new and, up to the present, unheard-of principles of operation. Wireless telephone systems may be divided into two classes, the first making use of a beam of light for transmitting the necessary vibrations, and the other employing the so-called leakage method. The first has been made use of by Bell, Simon, Duddell and Rühmer; the latter by Lindsey, Preece, Armstrong and Orling, and others.—*Abstracted from Telephony (Chicago), February.*

An Arrangement for Exact Standardization of Electrometers for Electrical Measurements, and Its Use for the Absolute Measurement of Very Small Currents.

The difficulty of eliminating external influences when determining the capacity of electrometers is here dwelt upon by Herr F. Harms, and a method described, developed by the author, for accomplishing this. The capacity of an electrometer is influenced considerably by neighboring conductors, and unless due precautions are taken errors of ten to fifteen per cent, or even more, may be made. In the author's arrangement a condenser consisting of two vessels, one contained in the other and both placed within a protecting vessel, is used. The protecting vessel and the inner inside condenser surface are connected to the ground. The outside condenser surface is connected to one terminal of the source of electromotive force, the other terminal being connected to the ground. The earth connection of the inner condenser surface is then broken, and the outer surface connected to the ground. In this way the charge held by the condenser will be unaffected by external bodies, and, knowing the coefficient of the condenser and the voltage, can then be computed. The author gives two methods for determining the coefficient of the condenser, illustrating these with actual examples.—*Translated and abstracted from the Physikalische Zeitschrift (Leipsic), January 15.*

Test of a Large Steam Engine.

The students of the Massachusetts Institute of Technology made, not long since, a complete test of one of the large Westinghouse units at the Lincoln Wharf power station of the Boston Elevated Railway Company, and the results of their work are here given. The test was complete in every detail. The unit to be tested was separated from the others, and was supplied by an independent boiler equipment. The duration of the test was forty hours. The principal dimensions of the unit are as follows: diameter of the high-pressure cylinder, forty-four inches; diameter of the low-pressure cylinder, eighty-seven inches; stroke, sixty inches; revolutions per minute, 74.37. The conditions of operation were: steam pressure at the throttle, 158.1 pounds; degrees of superheat, 69.70; vacuum, 11.8 pounds. The results of the test show that the total horse-power of the engine, from the indicator cards, was 3,902 horse-power. The steam furnished per horse-power per hour was 12.08 pounds, the corresponding British thermal units being 223.4. The thermal efficiency of the engine was eighteen per cent. The efficiency of Carnot engine, working between the same temperatures, would be 33.24 per cent, making the ratio of the engine efficiency to that of the Carnot engine 54.14 per cent. The mechanical efficiency of the engine was 92.8 per cent. The dry coal per electrical horse-power output per hour was 1.75 pounds. The boiler performance, analysis of coal and other important data are given in detail.—*Abstracted from the Technology Quarterly (Boston), December.*

Lines of Progress in the Efficiency of the Combustion Motor.

While noteworthy advance has been made in the development of prime movers, particularly of the rotary type, no corresponding development in the method of raising steam has taken place; and while the new rotary engines may have a high efficiency, they are still supplied with steam generated in a comparatively inefficient steam boiler. Mr. E. C. Warren here discusses this phase of power development, mentions what has been done previously, and describes a system proposed by himself. In this, oil supplied through an automatically controlled atomizing valve is mixed with the proper proportion of air, and burned in an enclosed chamber, the gas and air being forced into this chamber at a pressure about twenty pounds higher than that of the steam generated. This combustion chamber is contained within a steam boiler, so that it is surrounded on all sides by water, and at the top is in communication with the steam space. The combustion chamber is therefore subject to no pressure strains. The burned gases passing out from the combustion chamber mingle with and superheat the steam from the boiler, and the mixture is supplied to any suitable type of prime mover. The propor-

tion of air and oil is automatically controlled, as well as the supply of water. These features take care of any variation in the demand on the generator. The author estimates that with an engine having a mechanical efficiency of ninety per cent, and charging thirty-five per cent for exhaust radiation and leakage losses in the engine, and ten per cent for radiation and incidental losses in the pressure generator, a net efficiency of heat conversion of something like forty-five per cent may be realized, and this in a combination giving the compactness, safety and automatic features of the oil engine, together with the perfect mechanical operation and general reliability of the steam engine.—*Abstracted from the Engineering Magazine (New York), February.*

A Novel Wave Detector.

A novel wave detector has been developed by Mr. W. Schloemisch, which depends for its operation upon the sensitiveness of polarization cells with regard to electric waves. In the course of his investigations of the behavior of polarization capacities with regard to electric waves, the inventor noted that if an ordinary polarization cell with platinum or gold electrodes immersed in dilute acid is connected with a source of current, the electromotive force of which is a little higher than the back electromotive force of the cell (so as to have a slight evolution of gas on the electrodes in virtue of permanent decomposition current), an ammeter would give evidence of an increase in the current strength as soon as the cell was struck by an electric wave. This effect proved to be higher the smaller the dimensions of the positive electrode, and in the form developed the positive electrode consists of a wire 0.001 millimetre in diameter and 0.01 millimetre in length. The negative electrode, being of no essential importance, may have any desired dimensions and shape. The physical nature of the phenomenon in question is not understood at present, and it is not known whether the detector embodies a capacity or an ohmic resistance. There is a critical pressure difference for each individual detector, for which the sensitiveness is highest. But using as electrode materials two metals as distant as possible in the electromotive-force series so as to constitute a small galvanic cell, an auxiliary battery may be dispensed with. One of the important advantages afforded by this detector is its property of reacting to wave impulses proportionally to their intensity, thus showing a reaction even with low-intensity waves. It is constant and insensitive to shocks, and its sensitiveness is easily controlled by altering the pressure applied to the electrodes. It may be used both in connection with relays and telephones in receiving circuits.—*Abstracted from the Electrical Review (London), January 22.*

Phenomena in Connection with Mercury Arcs.

In this article an abstract is given of a paper presented by M. de Valbreuze at the French Academy of Sciences, in which are recorded some experiments which he made upon mercury arcs in U-tubes connected to a Sprengel air pump. On first being started, a uniformly luminous surface of varying size is presented by the anode, the pressure in the cold tube ranging between 0.004 and 0.002 millimetre of mercury. This surface soon becomes covered with small stars of great brilliancy, forming regular geometric figures, stars frequently being located in the angles and at the centre of a regular pentagon or hexagon. As the electrode becomes hot, the stars increase in size, assuming the form of spherical luminous pearls. These form groups, clinging to one another so as to give a luminous central disc and one or more concentric luminous rings separated by dark rings. Finally, the anode assumes the aspect of a uniformly luminous surface. Usually, to start an arc through mercury vapor a high potential is applied, but M. de Valbreuze has found that by applying a difference of potential of 550 volts, spontaneous starting may take place, under the following conditions: if the anode is a tube of iron, and cathode mercury, a beautiful violet light is observed above the cathode, and a slight greenish luminescence around the anode. The current passing through the tube is from 0.01 to 0.02 ampere, with a pressure of about 0.015 millimetre of mercury. In nearly all cases the normal arc is found to pass spontaneously for some minutes. If the pressure is less than that just mentioned, the same preliminary phenomena would be observed only when the tube is hot. The arc is seldom completed spontaneously under these conditions, but may be started by imparting a shock to the tube. Where both the anode and cathode are of mercury, phenomena of spontaneous starting are less frequent. If the mercury be stirred, the difficulties of starting the arc are decreased. The author thinks that there is a sort of surface membrane offering, especially in the cold state, high resistance to the passage of current; and that this plays a part also in all these phenomena. Geometrical figures are determined by the vibratory state of this membrane.—*Abstracted from the Electrical Engineer (London), January 15.*

Gas Pipe, Copper and Coal Truck.

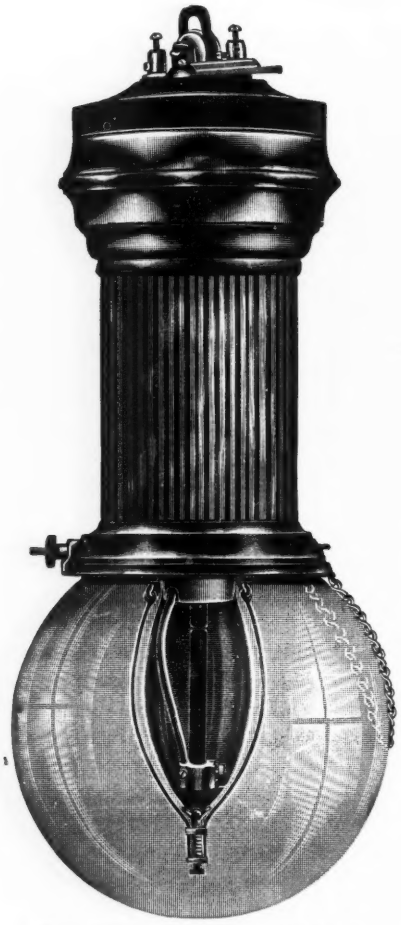
In a previous article comparisons were made of the transmission of 6,000 brake-horse-power by means of electricity and gas, for a distance of five miles. It was shown that the line costs, neglecting the cost of wasted units, were 0.25 cent with electricity, and with gas, 0.1 cent. In this article Mr. C. A. Smith considers the transmission of 1,000 kilowatts twenty-five miles, and to complete the comparison takes up also the possible economy of carrying coal instead of either gas or electricity. The cost of a 1,000-kilowatt main for electrical transmission is taken as $9,000 per mile. Ten per cent is allowed for interest and depreciation, and a twenty-five per cent load-factor assumed. The number of kilowatt-hours transmitted would be 2,190,000; and allowing an efficiency of eighty per cent for the transformers and rotaries, the energy metered at the substation would be 1,752,000 kilowatt-hours per year, and the line costs would be 1.21 cents per kilowatt-hour. Considering the transmission by gas, the brake load on the engines would be 1,340 brake horse-power, and the kilowatt-hours metered with an efficiency of eighty per cent for the generators would be the same as above. The consumption of gas assumed was seventy cubic feet per brake horse-power-hour, the total consumption per hour being 93,800 cubic feet. To transmit this gas, an initial pressure of five atmospheres is taken, and the diameter of the pipe is found to be six inches. The cost of this pipe is $50 per ton, and the total cost of compressor, pipe line, excavation, etc., is $90,000. Ten per cent is allowed for interest and depreciation, and with a twenty-five per cent load-factor, the line costs is found to be 0.5 cent per kilowatt-hour. The cost of carrying the coal necessary to produce this power on the premises from gas engines is estimated to be $1,500. The corresponding figures for gas transmission are $9,000, and for electric transmission, $22,500; but it is thought that the cost of producing gas at the station in sporadic quantities would be greater than that of the transmitted gas. Attention is called to a statement made by Sir Oliver Lodge twenty-two years ago. Sir Oliver thought that a revolution in methods of lighting, heating and power production was pending, and that the world was entering upon an epoch not of electricity only, but of electricity and gas. The author considers it strange that more progress toward accomplishing this has not been made.—*Abstracted from the Electrical Review (London), January 15.*

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

A New Type of Enclosed Arc Lamp.

The accompanying illustration shows the new Hipwell arc lamp recently placed on the market by the Hipwell Manufacturing Company, of Allegheny, Pa. These lamps are built to burn on all voltages, direct and alternating currents. The frame of the lamp is composed of a heavy cast crown to which the centre column tube is rigidly secured. The solenoid coils are secured to the centre tube in such a manner as to permit of ready removal if necessary. The manufacturer states that the clutch is positive in action, and will take a large variation in diameter of carbons, particular attention being called to the fact that a solid straight rod runs direct from the clutch to the dashpot, dispensing with lever springs, etc.



NEW TYPE OF ENCLOSED ARC LAMP.

MECHANISM OF ENCLOSED ARC LAMP.

The dashpot is composed of a heavy seamless drawn tube, with a German silver plunger in the form of a shell. The thickness of both tubes is the same, giving an equal expansion and contraction of the outer shell and plunger, which eliminates possibility of sticking. The upper carbon holder is fed by means of a flexible cable.

The resistance is wound on a porcelain bobbin secured to the crown of the lamp. The entire casing can be removed by loosening one screw on the crown, when every part of the lamp is readily accessible.

The globe or shade is held by means of a split ring which is secured firmly, eliminating chipping of the glass. The inner globe is held in a spring bearing, which allows for expansion of the globe when heated. The lamp is built on the interchangeable system, and all parts are a duplicate of each other.

The Recent Literature of the General Electric Company.

The publicity department of the General Electric Company, Schenectady, N. Y., has issued a number of booklets and circulars of information which form a valuable addition to the material already placed in circulation by this department. There is an index to the price lists, showing those which are available and those which are out of print. An index to fliers and an index to supply catalogues are of the same description, and price list No. 5120 gives prices on the principal repair parts of form 5 alternating-current multiple enclosed arc lamps. Flier No. 2125 describes and illustrates adapters for concentric diffusers. An index to bulletins shows those bulletins which are out of print and those which are available. Bulletin No. 4352 describes and illustrates CL generators; bulletin No. 4353, single-phase form L motors; bulletin No. 4354, belt-driven railway generators; bulletin No. 4355, motor-generator panels for automobile charging sets; bulletin No. 4356, small continuous-current stationary motors; bulletin No. 4357, automobile motors, and bulletin No. 4358, controllers for electric vehicles.

One of the handsomest souvenirs which has been produced for some time is entitled "The Lighting of New York City." There are illustrations in colors of a number of splendid views of the principal points in New York city, starting at the Battery and traversing the entire city. This booklet shows the extensive use which is made of the General Electric Company's arc lamps, which are used not only for street illumination, but also for interior illumination and decorative effects of every description. The booklet is handsomely bound in a heavy gray rag cover, with a three-color illustration of a typical night scene in New York city.

A Wire Testing Clip.

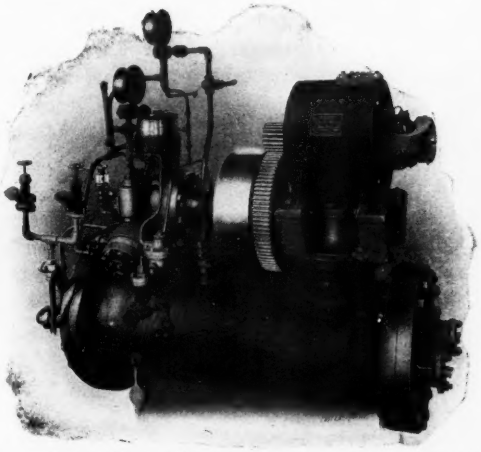
The function of the Frankel wire testing clip is readily seen from the accompanying illustration. In testing out circuits the wireman has to injure the insulation more or less severely when a knife is used. The idea of the Frankel clip is to perform the operation of holding the wire securely and tapping the circuit at the same moment. The clip makes a perfect contact without removing the insulation, the teeth holding the wire, and the pin sinking through the insulation, making contact. This device is manufactured by the Frankel Display Fixture Company, 718 Broadway, New York city.

WIRE TESTING CLIP.

Variable-Speed Motor for Refrigerating Apparatus.

The accompanying illustration shows a variable-speed motor built by the Rochester Electric Company, Rochester, N. Y., driving a refrigerating apparatus. This motor is of the compound-wound direct-current type, series field windings being used to give a large starting torque, together with slow speed. The series coils are short-circuited by the controller as the speed increases, the highest speeds being obtained by inserting resistances in the field circuit.

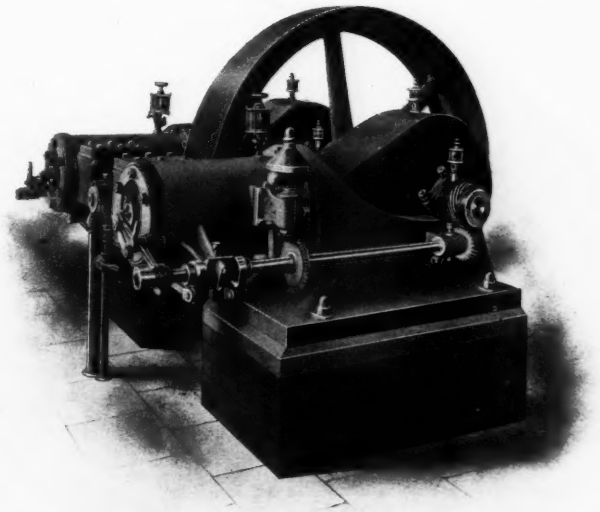
The pole-pieces are built up of punchings of annealed sheet iron, the shape of the pole-tips being such that they are saturated even under the weakest condition of the field. By this method the manufacturer claims that there is very little heat lost in resistance, and there is no sparking at the controller. As wide a variation as is required under ordinary conditions may be obtained by using a mechanical speed-changing device in connection with this method. The principal advantage the company claims is that with this method there is no unnecessary complication in the wiring, and no need of extra generating apparatus.



VARIABLE-SPEED MOTOR DRIVING REFRIGERATING APPARATUS.

The Harvey Automatic Railway Signal.

An automatic electric railway signal, operated by a solenoid and a relay, has been brought out by Estler Brothers, of 25 Laurence Pountney lane, London, England. The signal is operated by the trolley wheel running under contacts suitably placed above the trolley wire. These contacts are supported by short arms attached to brackets in side-arm construction, or from spans supported by the bells in span-wire construction. The contacts are flat plates suspended by springs about three-quarters of an inch above the trolley wire. The trolley wheel, in passing, makes a smooth contact between the trolley wheel and the plate, and thus transmits the current for a brief interval to the apparatus. This contact sends a current through the solenoid, raising the signal arm to a horizontal position, where it is held by a detent. As the car passes out of the section, the trolley wheel makes contact with a second plate, which, establishing a current through the relay in the signal box, releases the detent and allows the signal to fall to the clear position.



THE RUGER GAS ENGINE.

The Ruger Gas Engine.

A new type of gas engine has been recently placed on the market by the J. W. Ruger Manufacturing Company, of Buffalo, N. Y. This engine is of the graduated charge or throttling type—that is, the strength of the impulse is reduced by varying the quantity of the charge entering the cylinder, although the proportions of the fuel and air remain the same at all times.

The engines are built in sizes from 10 to 150 horse-power, and for electric lighting work are built on the twin engine plan. As may be seen from the illustration, this consists of placing the two engines side by side, the crank of the shafts being coupled together by a large and heavy flywheel between them, making substantially a single engine of the pair. The charge enters both cylinders through one throttling valve controlled by a single governor, although each cylinder has independent mixing and exhaust valves.

The valves are of the poppet type, set vertically, and both the mixing valve and the exhaust valve are operated mechanically. The valve governor and sparker mechanism is operated by a lateral shaft running along the side of the engine, and is driven by a pair of spiral gears. The governor is said to be extremely quick and sensitive in action, with positive control of the graduating valve, and admitting more or less of the gas mixture as required by the load upon the engine. The governor consists of two weights hung upon a vertical shaft, the weights being enclosed in a bonnet. The sparker is placed at the head of the engine, and is of the hammer-break type. This sparker is operated by a reversing cam on the shaft, in connection with a lever. The lever is balanced on an eccentric, so arranged that the time of firing can be changed while the engine is in motion. The sparker current is supplied by a small generator.

The cylinder is designed with a circular flange on the engine bed. The crank and connecting rods are forged from steel, and the cylinders, valve chest, head, etc., are cast from a special fine-grained tough iron, and are supplied with large capacity water-jackets. Cast-iron counterbalancers, of such a weight as to perfectly balance the engine, are fitted to the cranks.

A Russia iron shield entirely encloses the working parts of the engine and keeps out dust, at the same time preventing the throwing of oil by the counterweights on the crank. Phosphor-bronze babbitt metal, hardened tool steel, etc., are used for such wearing surfaces as experience has proved best adapted. All parts are easily accessible, and any part of the engine may be reached without disconnecting any other part.

A recent test for regulation on this engine by Messrs. McCarthy Brothers & Ford, when the engine was belted direct to a fifteen-kilowatt 110-volt compound-wound "Wood" generator, showed that there was a drop in speed of only about seven revolutions a minute, while the generator voltage varied but one volt from no load to full load.

Individual Fire-Pumping Station for Philadelphia, Pa.

Very often in congested districts of a large city a conflagration breaks out, and owing to the lack of pressure in the city water mains there is considerable difficulty found in checking the progress of destruction. From time to time there has been agitated in several of the larger cities of the United States the proposition looking toward equipping these cities with central pumping stations which will be entirely independent of the waterworks system. It is quite possible to carry high pressure in the regular service mains, but this would increase the cost of maintenance on such a pipe line, due, of course, to the construction already laid down not having been worked out for such pressures; and there are also other difficulties, such as leakage and increased number of fittings, which make this rather impractical.

The city of Philadelphia, Pa., has for a long time been the subject of much criticism on the part of fire underwriters and business men in general, because of the rather bad conditions of water supply in the city. Within the past three or four years this has been materially improved; but while the fire-fighting apparatus is of the most modern description, the water mains are not in the same class.

There has recently been completed in the city of Philadelphia, on the Delaware river front, at the corner of Race street and Delaware avenue, a gas engine pumping plant which will be used exclusively for fire service. The fuel supply for this plant will be taken from the city illuminating gas mains. It has always been a question, ever since a plant of this nature has been considered, as to what form of motive power would be used. Electricity has often been suggested, and there could probably be no better form of prime mover than a well-constructed motor. But apparently the Philadelphia authorities were fearful of a breakdown in the service. The city of New Orleans, La., is an object lesson as to the absolute value of the electric motor as a means for giving service of this nature which should not be neglected by any one. The very large number of electric pumping stations in mines, both in the United States and abroad, also show to what extent the motor is relied upon for this service.

However, gas engines have been chosen for the motive power of this municipal installation, and that they will do the work with every satisfaction there is no doubt. The pumping station occupies a building 72 by 140 feet, and will contain ten eleven and one-half by twelve-inch vertical direct-acting Deane triplex pumps, each capable of delivering 1,200 gallons per minute at forty revolutions, against a pressure of 300 pounds per square inch. There are also two six and one-quarter by twelve-inch pumps of the same type, of 350 gallons capacity per minute. These pumps are to work together or singly, as may be desired, and all will discharge into a common twenty-inch main. The water for the supply of the pumps will be taken directly from the Delaware river through a thirty-six-inch suction main. Only seven of the larger pumps are being installed at present. Each of the large pumps will be driven by a 280-horse-power Westinghouse three-cylinder single-acting gas engine, and the small pumps by engines of the same type, of 125 horse-power each. The smaller engines will be direct-connected to the smaller pumps by means of friction clutches, and will also drive electric ignition generators of seven and five-tenths kilowatts capacity each, together with the air compressors supplying air at 200 pounds pressure for starting the main engines.

There are three sources of current for ignition—the connections with the city lighting mains and a storage battery being provided in addition to the ignition generators. The lighting current is reduced from 220 to 110 volts by a rotary transformer. Cooling water for the gas engine cylinders may be taken from two different city water mains and from the fire mains. A gas pressure regulator on the supply pipe of each engine maintains the pressure constant.

The pressure in the fire mains is controlled automatically by an electric motor acting on a valve. It may be held steadily at any point under 300 pounds, while a spring relief valve prevents it from rising above that amount.

The machines were especially designed for fire service by the Deane Steam Pump Company, of Holyoke, Mass., and are fitted throughout with material of such dimensions as will give them the largest possible factors of safety.

The mains supplied by this pumping station are nine miles long, and consist of pipes eight, twelve and sixteen inches in diameter. They are of extra thickness, and all fittings, including fire plugs, are of special design. The total weight of the pipe is 6,500,000 pounds, and of the fittings, 856,000 pounds, costing altogether $355,000. The pumping house cost $250,000, and the large units $22,000 each, the small ones costing $8,000 each.

The station replaces with advantage more than forty fire engines, and as a result of its installation, the rate of insurance in Philadelphia will be reduced twenty-five cents per $100.

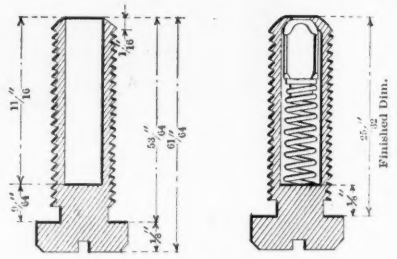
A Diamond-Bearing Meter Screw.

John Wennstrom's Sons Company, 354 Forty-first street, Brooklyn, N. Y., one of the pioneer manufacturers of jewel meter bearings, has developed a new form of meter screw for current registers, which has proven of great value to central station men.

One of the most persistent difficulties with which central station operators have to contend is the tampering with meters by their customers. There are many tricks which the dishonest customer plays upon the electric company, and the carrying out of some of the malicious ideas results in rendering the meter unfit for service.

Another difficulty, and one which goes hand in hand with the tampering with meters, is the wearing out of the jewel bearing which carries the pivot of the rotating member of the meter. Mr. Wennstrom is now making his pivot bearings of diamonds, instead of the commonly used sapphire.

The accompanying drawing shows the construction of a new meter screw, some 9,000 of which Mr. Wennstrom has supplied to the New York Edison Company,



DIAMOND-BEARING METER SCREW.

and about half as many as this to the Brooklyn Edison Company. The screws are made of certain lengths and with certain threads, according to the meter with which they are to be used.

The brass screw proper is made in the ordinary way, and seated within the hollow of this is a finely tempered spring. Resting upon the spring is a brass stub. In this brass stub there is then inserted a steel collar carrying the diamond bearing, and immediately above the diamond bearing is placed a sapphire bushing.

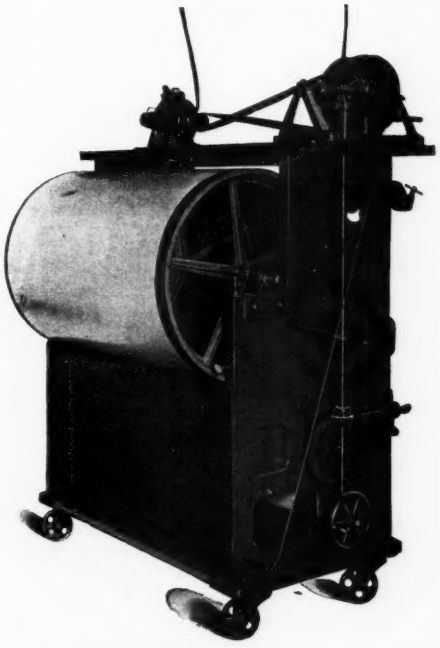
In order to obviate any possibility of the bearing being punctured, a rough diamond is set into the steel collar, having at least twice as great a thickness as the ordinary jewel. This is then faced off even with the top of the steel collar, and the sapphire bushing placed on top of this.

The manufacturer states that the life of this bearing is some 18,000,000 revolutions, and wherever it has been used it has given the greatest satisfaction.

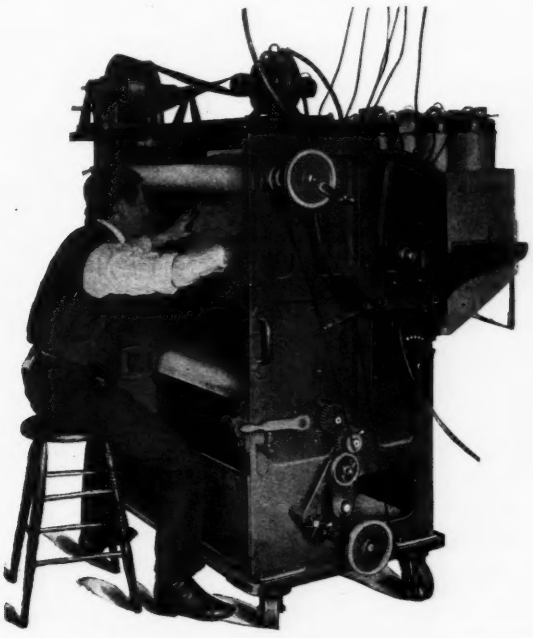
An Electric Blue-Printing Machine.

The accompanying illustrations show a new type of blue-printing machine manufactured by the Spaulding Print Paper Company, Incorporated, 44 Federal street, Boston, Mass.

The principal parts of this machine consist, first, of a drum, revolving freely in roller bearings; a feed or let-off roll above this drum, carrying a long, transparent flexible apron; a pair of pulling rolls under the drum, and connected to the power through a patent speed-controlling mechanism. The transparent apron is drawn from the feed roll against a tension device around the surface of the drum, surrounding the latter for about one-half of its circumference. The transparent apron, which is in contact with the face of the drum, constitutes the exposing surface for printing.



BLUE-PRINTING MACHINE WITH ARC LAMPS REMOVED FOR SOLAR PRINTING.



ADJUSTING THE TRACING AND TRANSPARENT APRON, ELECTRIC BLUE-PRINTING MACHINE.

The tracings and blue-print paper are fed between the apron and the surface of the drum at the top of the machine, and are carried around as the drum revolves, in this way being exposed to the action of either sun or electric light; and afterward drop out automatically into a box provided for the purpose.

The size of blue-prints that can be taken by this machine is limited only by the width of the drum and the length of the transparent apron. An ordinary roll of tracing cloth is twenty-four yards long, and will be found sufficient for almost any drawing made.

Exposures can be made either on a continuous roll of blue-print paper or on separate sheets. If a continuous roll is used, the end of the paper is started under the transparent apron on the upper surface of the drum, and the tracings are placed, one after the other, upon it as the drum revolves. The chemical side of the paper is toward the operator. The tracing is placed right side up on this surface, and the operator can see just where to place the tracing with relation to the blue-print paper. After the exposure has commenced there is no possibility of the tracing slipping.

The speed of printing depends on three factors, *viz.*: the sensitiveness of blue-print paper, the transparency of drawings, and the amount of light available. The speed of the machine is under perfect control, and by moving a handle either to the right or left, all the variations that may be required for fast or slow printing are instantly made while the machine is running.

The arrangement of lamps is shown in the accompanying illustrations. Enclosed arc lamps of five amperes each are used, arranged side by side in a reflector placed in front of the exposing surface. Four of these lamps are used in the thirty-inch machine, six in the forty-two-inch machine, and seven or eight in the fifty-four-inch size. The arcs burn for about 130 hours continuously, giving a perfect and uniform illumination over the entire width. In case the full width of the drum is not used, one or more of the lamps may be cut out.

The apparatus is made interchangeable, so that one machine may be used for both sun and electric printing if it is found economical to use sunlight when it is available. The change is quickly made from electric to sunlight printing, by slipping out the reflector which holds the lamps, and removing two brackets from the machine. It is ready for exposure by sunlight by rolling the machine out where the direct rays of the sun can fall on the exposing surface of the drum.

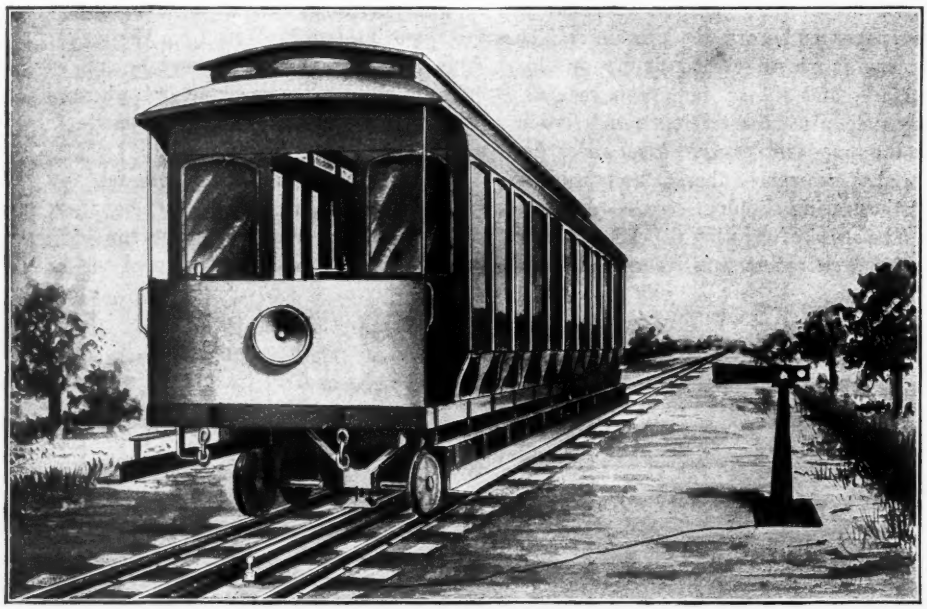
The power for the machine is taken from a small electric motor of one-quarter horse-power, fastened on the top of the machine and belted to the speed controller. A flexible wire of sufficient length to allow of moving the machine to any part of the room is furnished.

A Calendar of Invention and Discovery.

An interesting calendar of invention and discovery has been compiled by Mr. J. C. Wait. On each left-hand page for every day there are biographies of two noted persons who have contributed materially to the industrial progress of the world. Discoveries and inventions made by them, and their great works, are also noted briefly. In addition, quotations from classic literature, descriptive of science or art, are included. The right-hand pages are blank for daily memoranda and notes. The calendar is published in the wall or desk form, 60 cents; pocketbook, cloth, $1, by the McGraw Publishing Company, 114 Liberty street, New York city.

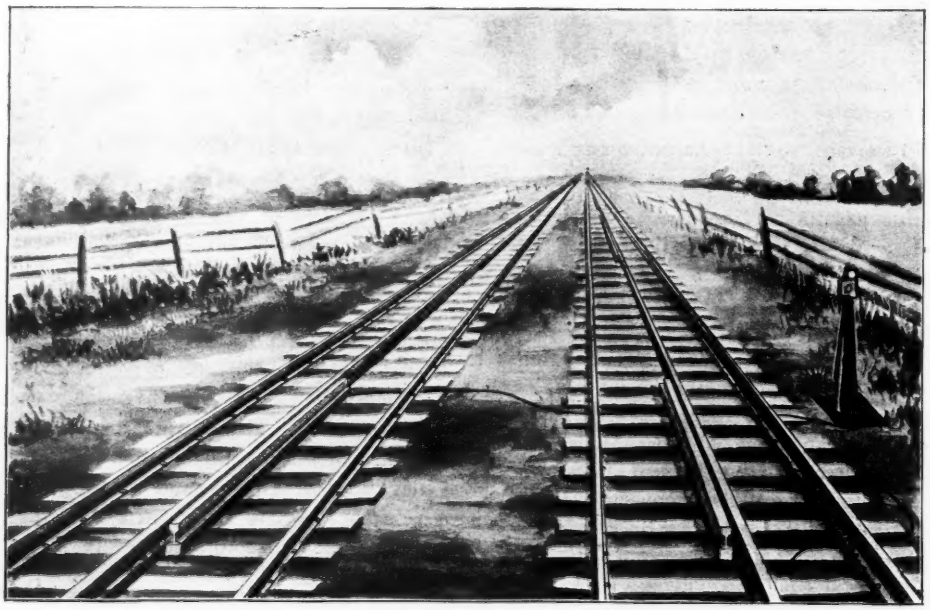
A Simple Electric Railway Signal System.

Mr. William H. Jordan, New York city, is the inventor of a decidedly simple electric railway signal system. While simple in characteristics, this system is extremely broad in its application. Briefly, the chief feature is the use of the main line current for operating any system of electrical signaling apparatus. The accompanying illustrations show the application of the signal system to a third-rail conductor. A shoe or other contrivance is carried on the car, and makes contact between the main line conductor and a section of signal rail or wire, forming a divided circuit, a portion of the current passing through the proper signaling apparatus, which may be in the form of a bell, a semaphore arm or a series of lights and then grounding.



ELECTRIC RAILWAY SIGNAL SYSTEM, CONNECTED WITH THIRD RAIL SECTION.

In the system, which is illustrated herewith, only a section of signal rail is used. In this case the current operates a solenoid, which throws the signal arm in position in the daytime and lights a series of lamps at night, as the car enters a block section. As this car leaves the block at the other end, current is caused to flow in a similar magnet, which thus throws the arm or the lights to "clear."



ELECTRIC RAILWAY SIGNAL SYSTEM, USING SHORT SIGNAL CONTACTS AT ENTRANCE AND EXIT OF BLOCK.

In other ways this method of using the main line current has been employed with success. In one method the right of way is divided into blocks, the signal wire for each block being insulated from the block immediately before and after it. In this case, however, it is necessary to have a continuous signal line for the whole distance of a block. This causes a signal lamp to burn, or a semaphore arm to show danger, as long as a car is on the block and current is flowing through the signal apparatus. To further increase the utility of this system, an annunciator in series with the signal box may be installed in the despatcher's office, the signal wire grounding at the despatcher's office instead of at the signal box.

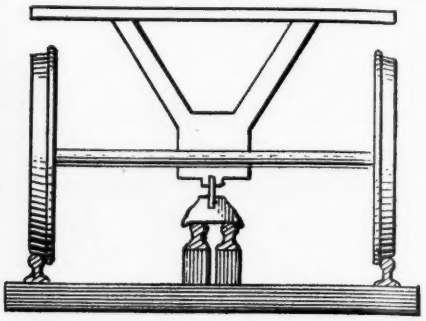


DIAGRAM SHOWING SCHEME OF CONTACTS.

This system eliminates the use of local batteries, and as the current is used from the line operating the cars, almost any form of signal apparatus may be installed. The system is patented and manufactured by Jordan Brothers, 74 Beekman street, New York city.

Portable Electric Pumps.

The City of London (England) Company has made good use during recent heavy rains in that city of a portable pump driven by an electric motor for draining flooded basements. The pump is kept in readiness and may be obtained at a few minutes' notice, current being drawn from the supply mains. It is reported that the company is now considering the establishment of a portable fire engine, to be worked in a similar manner.

Supplies for Exposition Purposes.

It is understood that the contract for motors for the electric launches to be used at the St. Louis Exposition has been awarded to the Hertner Electric Company, of Cleveland, Ohio, and that the storage battery equipment for these launches will be furnished by the Willard Storage Battery Company, also of Cleveland, Ohio.

BOOK REVIEWS.

"The Locomotive Simply Explained." Charles S. Lake. London. Percival Marshall & Company. Paper. 5 by 7 inches. 72 pages. Illustrated. Supplied by the ELECTRICAL REVIEW at 25 cents.

This is vol. xvii of the Model Engineers' Series, and is a first introduction to the study of the locomotive engine. The functions and construction of the various parts of a locomotive are explained clearly and in detail in the first two chapters. Chapter three is descriptive of modern locomotive types, giving a general classification, and chapter four consists of a brief locomotive catechism.

"Architectural Perspective for Beginners." F. A. Wright. New York. William T. Comstock. Cloth. Eleven plates with notes. 11 by 14 inches. Supplied by the ELECTRICAL REVIEW at $3.

In preparing the plates used in this work on architectural perspective for beginners, the author, who is a practical architect, has kept in mind mainly that class of draughtsmen who are obliged to be self-taught. Even with careful instruction the theory of perspective is, to some minds, rather hard to grasp. The method which the author pursues in taking up this study is very practical, and the first plate and its supplementary notes give the beginner a good idea as to the process to be followed in producing perspectives from the diagram and elevations. It seems peculiar that the author does not take up the fundamental theory of perspective until several plates have been worked up, but the student can probably rely on his judgment, in that he deems it best to make the student familiar with other salient points before taxing the understanding too greatly. Some excellent illustrations of shading, both in free-hand and with the drawing-pen are given, and particularly for those draughtsmen who have not had the benefit of a technical course, and who depend for their improvement upon the work which they have to perform for a living, the book will be of value.

Proposed Railway School for McGill University.

The board of governors of McGill University, Montreal, Canada, has under consideration a proposal to found a school of railroad engineering and transportation in connection with the university. The project was first suggested by Sir Thomas Shaughnessy, president of the Canadian Pacific. It is estimated that $20,000 will be required to pay the running expenses of the new course. Of this amount, the Grand Trunk and Canadian Pacific railways have promised to subscribe $5,000 each annually, while the Canadian Northern will give $2,000. The government will be asked to contribute a sum in the name of the Intercolonial Railway. The ground to be covered will include location, including all branches of survey; construction, including the laying out of work, the construction of bridges, buildings, track-laying and ballasting, organization and specifications; operation, including maintenance of way and structures, the conducting of transportation, and equipment, organization and legislation. The preliminary task of drawing up a plan of studies has been entrusted to a committee, which has been consulting with Mr. F. W. Morse, third vice-president of the Grand Trunk, and Mr. E. H. McHenry, chief engineer of the Canadian Pacific Railway.

The British Institution of Electrical Engineers.

At a meeting of the Manchester section of the British Institution of Electrical Engineers, held January 19, a paper was read by Mr. A. S. Giles, on "Coal Consumption in Central Stations." In order to study this question, the coal consumption in the weaving and spinning mills of Lancashire was investigated. A table was given, showing the thermal value of the various grades of coal used there, and full statistics of the kind of power equipment and its performance are shown.

At a meeting of the Dublin section a paper was read by Mr. William Brew, entitled "Three-Phase Working, with Special Reference to the Dublin System." In this paper some interesting features of that plant, which consists of two 1,000-kilowatt and two 500-kilowatt Oerlikon generators, driven by marine type compound engines with Corliss valve gear, were discussed.

Underground Telegraph Lines in England.

Work has been proceeding rapidly during the last few months laying an underground telegraph cable between Birmingham and Warrington, England. The cable consists of 103 wires, enclosed in a lead sheath, and is laid in a three-inch cast-iron pipe. Seventy-four wires are twisted in pairs, the remainder being single wires. It is thought that the pairs of wires may be used for telephone service, as well as for high-speed telegraph circuits. At Warrington the underground lines connecting Liverpool and Manchester can be tapped, and it will then be possible to telegraph from London to Liverpool by means of underground wires. A line is also being laid northeast from Manchester, to serve the large Yorkshire towns, as it is thought that next year the post office department will lay the section between Warrington and Carlisle.

Proceedings of the National Electric Light Association.

The report of the twenty-sixth convention of the National Electric Light Association, which was held at Chicago, Ill., May 26, 27, 28, 1903, is ready for delivery. The report makes a handsome volume of about 900 pages, is well printed and substantially bound in dark green cloth, stamped in gold. This volume is for members of the association and well merits the value they place upon it. In addition to the valuable papers and committee reports, the discussion and "Question Box" are of the greatest interest and practical worth.

American Institute of Electrical Engineers.

ASSOCIATES ELECTED FRIDAY, DECEMBER 18, 1903.

Charles E. Bernays, Brisbane, Queensland.
Robert V. Bingay, Pittsburg, Pa.
Albert P. Boeri, Brooklyn, N. Y.
John Frederick Bratney, St. Louis, Mo.
Grenville T. Bridgman, Schenectady, N. Y.
George A. Burnham, Willimantic, Ct.
John Herbert Carr, North Adams, Mass.
Thomas Bailey Carter, St. Louis, Mo.
Crellin Cartwright, Schenectady, N. Y.
Frank S. Culver, Madison, Wis.
Harry W. Cleland, Wilkinsburg, Pa.
Frederick Monroe Conlee, Madison, Wis.
Howard Harper Denn, Philadelphia, Pa.
Herschel George Fetherling, Madison, Wis.
William Gallaher, St. Louis, Mo.
Heatley Green, Potsdam, N. Y.
Tomokichi Hirokawa, Kyoto, Japan.
John Howard Hudgson, Philadelphia, Pa.
Frederick William Huels, Madison, Wis.
John Borland Ingersoll, Pittsburg, Pa.
Isaiah Jarcho, New York city.
John Wesley Kelly, Philadelphia, Pa.
Thomas Francis Kelly, Chicago, Ill.
Arthur Charles King, Madison, Wis.
William Leonard Kinsell, St. Paul, Minn.
Keigiro Kishi, Tokyo, Japan.
Arthur Bryson Kratz, Cleveland, Ohio.
M. T. A. Kubierschky, Berlin, Germany.
Justus Claude Lawler, Colorado Springs, Col.
George Hubbell McKelway, Brooklyn, N. Y.
Joseph Treanor McNaier, New York city.
Charles Messick, Jr., New York city.
Kadzuo Morita, Sagami, Japan.
Ned Earnest Newton, Philadelphia, Pa.
Iwaichi Notomi, Tokyo, Japan.
Harold Wilberforce Price, Toronto, Ontario.
Lewis John Ritschy, St. Louis, Mo.
Elmer H. Schwarz, New York city.
Soichiro Shimidzu, Tokyo, Japan.
Angus Sinclair, New York city.
Clement Alfred Smith, Valparaiso, Chili.
Emor A. Smith, Hartford, Ct.
Frederick C. Sutter, Pittsburg, Pa.
Samuel Newton Taylor, Allegheny, Pa.
Peter Gansevoort Ten Eyck, New York city.
Pendleton G. Watmough, Jr., S. I., N. Y.
Charles Harvey Wright, Toronto, Ontario.
Hugo Wurdach, St. Louis, Mo.
John G. Wynn, Madison, Wis.
James Watts Young, Philadelphia, Pa.

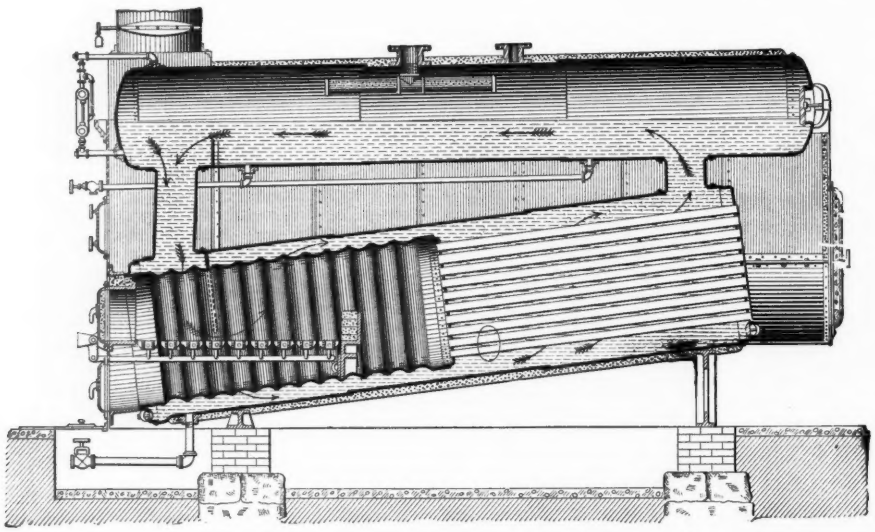
TRANSFERRED FROM ASSOCIATE TO THE GRADE OF MEMBER.

H. L. Reber, St. Louis, Mo.
F. O. Blackwell, New York city.
E. E. Stark, San Francisco, Cal.

The Robb-Mumford Internally Fired Boiler.

The accompanying drawing presents a sectional view of the Robb-Mumford internally fired boiler. This boiler combines the advantages of the Scotch and English types of internally fired boiler, together with light weight, little floor space and good circulation of the American water-tube type.

The boiler consists of two cylindrical shells, the lower one containing a round furnace and tubes, and the upper forming the steam drum, the two being connected by two necks. The lower shell has an incline of about one inch per foot from the horizontal, for the purpose of promoting circulation and draught, and also for convenience in washing out the lower shell. Combustion takes place in the furnace, which is entirely surrounded by water; and the gases, after leaving the furnace, pass through the tubes and return between the lower and upper shells to the outlet, which is at the front of the boiler.



THE ROBB-MUMFORD INTERNALLY FIRED BOILER.

The water and steam formed by contact with the furnace and tubes circulate rapidly up the rear neck into the steam drum, where the steam is released, the water passing along the upper drum toward the front of the boiler and down the front neck. A semi-circular baffle plate around the furnace causes the down-flowing water to circulate to the lowest part of the lower shell under the furnace.

The outer casing, including the rear smoke-box, side walls and smoke outlet, as well as the front and back, is constructed of steel plating with angle-iron stiffeners, various sections being bolted together for convenient removal. Asbestos air cell blocks are fitted between the angle-iron stiffeners on the inside of the casing and rear smoke chamber. The top of the upper drum and bottom of shell are also covered with non-conducting material after the boiler is erected.

The boilers, when set in batteries, are placed side by side with the shells six inches apart. The large open spaces underneath and between the upper and lower drums give access to the hand-holes and all the exterior parts of the boilers. By this arrangement a battery of seven units, which will develop 1,400 boiler horsepower, with a good margin for overloading, occupies a floor space of only forty-six feet in width by twenty-three feet in depth and thirteen and five-tenths feet in height. Each unit is entirely independent and may be completely isolated for cleaning, inspection or repairs.

The furnace is of the corrugated type for high pressures, and for low pressures Adamson expansion joints are used. These provide perfectly for unequal expansion and contraction, and require no staying. The heads of the steam drum are spherical, having a radius equal to the diameter of the drum. The tube sheets are perfectly stayed by the tubes. As the boiler consists of two plane shells or steam and water drums, similar to those used in water-tube boilers, and the construction entirely of steel plate of the required tensile strength and ductility, without cast-iron sections or headers, it is, the manufacturer states, as safe as any of the sectional or water-tube boilers on the market. The water in the boiler is comparatively small in volume, and well subdivided. The high temperature of the fire-box is taken care of by the corrugated furnace, and the outer surface of the shell is not subject to high temperature and unequal expansion.

The feed water enters at the rear part of the upper drum, and as it flows toward the front, the temperature is raised to that of the steam and water in the boiler, and an opportunity is given to deposit any sediment or solvent impurities on the bottom of the upper drum, particularly in the pocket formed by a baffle plate which is placed back of the front neck. At this point a blow-off outlet is provided. There is another pocket for the deposit of sediment, and the blow-off underneath the furnace, so there are practically two mud drums for the deposit and removal of sediment before the inflowing water reaches the hot surfaces of the furnace and tubes where scale would be formed.

The tests and practical experience, extending over several years, have shown that these boilers are possessed of a remarkably high efficiency. The boiler has been manufactured by the Robb Engineering Company, of Amherst, N. S., in its present form for the past six or seven years, and sold throughout Canada with great success.

The main office of the Robb-Mumford Boiler Company is at 170 Summer street, Boston, Mass., branch offices being located at 135 Broadway, New York city; 811 Lewis Block, Pittsburg, Pa., and 1102 Marquette Building, Chicago, Ill.

The Doherty Gold Medal Competition.

The National Electric Light Association is sending out a notice to members regarding Mr. Henry L. Doherty's offer of a gold medal for the best and most practical paper on underground construction. At the Cincinnati convention Mr. Doherty in his presidential address called attention to the necessity of mature consideration of underground construction. To stimulate the greatest possible effort in producing a text paper on the subject of underground construction, Mr. Doherty offered a gold medal, which would be properly inscribed, to the contributor offering the most complete and comprehensive paper on underground construction for either alternating or direct-current plants, or a combination of both, the selection of the best paper to be made by a suitable committee to be appointed by the then incoming president of the association. The competition is now open to all wishing to contribute a paper on this subject. Papers must be received at the office of the association not later than April 21. Three copies of each paper are requested.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

PROPOSAL FOR NEW CABLE—Senator Mitchell, of Oregon, has introduced a bill to authorize the North American Telegraph and Cable Company to lay cable and telegraph lines from the state of Washington, *via* Alaska, the Aleutian Islands, Siberia, Manchuria, China and Japan, to the Philippine Islands. A provision requires communication with the Aleutian Islands to be established within five years.

ELECTRICIANS HONORED BY THE KAISER—In recognition of their services to the state, Emperor William has had decorations conferred upon Dr. Schulz, president, and Herr Rathenau, general manager of the General Electric Company, of Berlin; Herr Denninghoff, manager of the Society for Experimentation in Rapid Electrical Transit, and on several engineers who have been connected with the recent experiments.

TROLLEY CONSOLIDATION—It has been announced in Columbus, Ohio, that a corporation is being formed, to be known as the Ohio Union Traction Company, of Columbus, with a nominal capital of $10,000. The incorporators are Richard Murray, W. A. Morgan, Harry I. Dowd, George E. Thomas and Otto F. Ehring. The intention is to complete the consolidation of several traction lines, giving a through service between Cincinnati, Columbus and Cleveland.

NEW AUSTRALIAN POWER STATION—Contracts for the additional steam plant have just been let by the New South Wales (Australia) Government for the power station of the Sydney City & Suburban Tramways. The lines already in operation are about seventy miles in length, and more are being built. The initial equipment of the plant, consisting of General Electric generators, Allis engines and Babcock & Wilcox boilers, will be increased to a capacity of 5,000 horse-power.

WISCONSIN ELECTRIC DEAL—The Construction Company of North America, New York city, has secured control of one of the most important interurban railways in Wisconsin. The company has been building the interurban line from Sheboygan to Plymouth, and the new power-house of the Sheboygan Light, Power and Railway Company, and with the securing of control will come the transfer to the New York interests of the local electric system as well. The properties are worth about $1,000,000. The importance of the deal lies in the fact that this line will be the vital link in the road from Fond du Lac to Kaukauna, forty-five miles in length.

PROGRESS ON VIRGINIA POWER PLANT—The annual meeting of the stockholders of the Virginia Passenger and Power Company was held at Petersburg, Va., on February 1. The following directors were elected: P. Sitterding, William H. Northrup, J. D. Patton, of Richmond; Frank J. Gould, Edwin Gould, Alfred Skitt, A. M. Cater, Guy Phillips, of New York, and Augustus Wright, of Petersburg. The company is now building an immense dam in Dinwiddie County, five miles above Petersburg, to furnish water power for two electric plants, to be established, one at the dam and another at the locks, two miles above the city. The dam, with the two plants, will cost $1,500,000.

TELEPHONE COMBINATION IN WEST VIRGINIA—Announcement is made of the establishment of a telephone combination controlling 2,000 miles of wire and 15,000 telephones in West Virginia. This combination is composed of the National, Consolidated, Beeghly, Buckhannon, Burton, Mannington, Exchange, Cameron, Harrison County, Belmont, South Pennsylvania, Pine Grove, Union and Flushing Telephone companies, operating in West Virginia, western Maryland, western Pennsylvania and eastern Ohio. It will be known as the Tri-State Toll Association, and its chief offices will be in Wheeling, W. Va. The officers elected are J. W. Barnes, Fairmont, president; A. H. Doudna, Bridgeport, Ohio, vice-president, and W. C. Handlan, Wheeling, secretary.

SOUTHERN NEW ENGLAND TELEPHONE COMPANY'S YEAR—The annual meeting of the stockholders of the Southern New England Telephone Company was held on the afternoon of January 26, in the general offices at New Haven. The report of President Morris F. Tyler showed a most satisfactory condition of affairs, the increase in the amount of business during the year being the greatest in the company's history. The total number of stations now in operation, belonging to the Southern New England Telephone Company, is 26,619. The net increase during the year 1903 was 5,509. There has been added 16,407 miles of wire to the plant, and common battery systems have been installed in New Haven and Bridgeport, where new buildings have been erected. New operating exchanges have been established in Cheshire, Farmington, New Canaan, Pawcatuck and Westport, and the company has negotiated with the four sublicensee telephone companies in the state—Bolton-Coventry, Orange, Lebanon and Huntington—to facilitate the telephone service for subscribers in farming districts. The total earnings for 1903 were $1,114,214.07. The total expenses were $897,226.11, leaving the net earnings $216,987.96, of which, when dividends were deducted, there was carried to surplus $29,937.96.

THE NEW YORK CENTRAL PLANS FOR ELECTRIFICATION—Plans to eliminate all grade crossings on the Hudson River and Harlem divisions of the New York Central Railroad have been drawn and submitted to the local authorities of Yonkers, Mount Vernon, Irvington, Tarrytown and Ossining. The local and the township authorities between the Harlem river and Croton, on the main line, and White Plains on the Harlem division, are also considering plans for the several sections of the railroad passing through their territory. As soon as the necessary consents and agreements of the municipal, village and county officials are obtained, the New York Central will begin the reconstruction of its roadbed for thirty-five miles north of New York city, and the laying of an electrical third-rail system over or under all the streets, roads and highways now crossed at grade. Under the general act of 1897, the cost of abolishing grade crossings is to be borne one-half by the railroad, one-quarter by the state, and one-quarter by the locality affected. In case the mayor and aldermen of any one of the five more important places named should refuse to agree to bear its proportion of the cost of the improvement, the board of railroad commissioners may decree that the work shall be done, and the proportion of its cost be paid by the municipality benefited. It is also announced that two large power-houses, to furnish current for the electric locomotives which are to supersede the steam locomotives between New York city and Croton and White Plains, will be built at Yonkers and Port Morris. The estimated cost of these power-houses is $2,500,000 each. Contracts have been let for the most important parts of the equipment, and their delivery is to be complete by July 1, 1906. The General Electric Company is now building eight steam turbines of 7,000 horse-power capacity each for this electrification. While full details of the plans for electrical equipment are not yet available, it is expected that an expenditure of $20,000,000 is contemplated.

LEGAL NOTES.

ORDER TO TELEPHONE COMPANY—The American Bell Telephone Company is ordered to give an accounting to the Western Union Telegraph Company, the successful plaintiff in a damage suit against the telephone company, by Judge Colt, in the United States Circuit Court, at Boston. Judge Colt also appointed Everett W. Burdett special master to take charge of the accounting and to hear all evidence that may be presented.

CAN NOT COLLECT TAX ON ELECTRIC LIGHT POLES—Judge Edward W. Biddle, at Carlisle, Pa., on February 2 handed down a decree dissolving the preliminary injunction recently granted against the Carlisle Gas and Water Company in the suit of the borough of Carlisle. The complaint in the bill of equity filed was that the gas and water company was about to erect poles without obtaining a license from the burgess to do so, according to the ordinance of 1902. Under this ordinance the sum of $1 must be paid for each pole erected under a license. The Court holds that such a charge can only be made as a police regulation, and not to raise revenues for general purposes; and, further, there was no evidence to show the actual expense to the borough, and therefore the Court was not warranted in finding that the ordinance was lawful, or the license fee reasonable in amount.

ELECTRIC LIGHTING.

SALT LAKE CITY, UTAH—Morgan is to have an electric light system.

EASTON, PA.—The business men of Hope are organizing a company to put in a small electric light plant.

DOYLESTOWN, PA.—It is stated that Coatesville capitalists will install an electric light plant in that city.

MANCHESTER, VT.—The Manchester Light and Power Company has purchased the Vail company's system.

MILLTOWN, N. J.—The borough council is considering the matter of establishing a municipal electric light plant.

FLINT, MICH.—An investigation made by the special lighting commission shows that the city can install a lighting system for $28,000.

GLEASON, TENN.—There is some talk of Gleason putting in an electric light plant, to be run in connection with the West Tennessee mills.

PROSSER, WASH.—The Prosser Falls Land and Irrigation Company has applied to the Prosser city council for an electric light franchise.

WILMINGTON, DEL.—The Wilmington City Electric Company has decided to install a switchboard costing $4,000 to improve its lighting service.

ALLENS CREEK, TENN.—The Bon Air Coal and Iron Company has recently installed an electric plant here to light its plant and a number of residences.

TIFTON, IND.—Tifton's municipal electric light plant is to be enlarged and the old dynamos taken out and replaced with machines of twice the present capacity.

OLYPHANT, PA.—The newly installed electrical machinery at the borough's plant has been placed in operation, enabling the system to supply about 3,000 additional lights.

DUBUQUE, IOWA—The Union Electric Company will start work on its new power-house as soon as possible. The plant will cost between $25,000 and $30,000, and will be modern in every detail.

GREENE, N. Y.—The proposition for raising an additional $4,500 to complete the municipal electric system, which was submitted to the taxpayers of the village, has been carried by a large majority.

SANDERSVILLE, GA.—A contract for the erection and completion of a system of waterworks and electric lights for Sandersville has been let to J. H. McKenzie & Son, of Augusta, the price being $40,000.

TROY, N. Y.—While no definite plans have been made as yet, it is considered probable that the Hudson River Electric Power Company will extend its cables and wires to Granville and other Washington County towns.

ST. JOSEPH, MO.—The proposition to issue bonds to the amount of $100,000 to construct a new electric light and power plant at Hannibal, was carried by a majority of eight to one, the vote being 881 for and 130 against.

WINSTON-SALEM, N. C.—The special committee appointed by the board of aldermen to report on the advisability of the erection of a municipal electric plant recommends that a plant be installed at once. Power could be obtained from Belos Pond.

KANKAKEE, ILL.—The Electric Light Company has decided to build a new cement dam this summer. Work will begin when the water reaches low stage in July, and pushed to completion in two months. The cost will be between $10,000 and $15,000.

BEAVER, PA.—Articles of incorporation have been filed by the Beaver Electric Company, in which W. H. Irons, of that city, is interested. It is the intention of the company to supply current for light, heat and power to Beaver and adjacent territory.

NASHVILLE, TENN.—It is said that the Great Falls Power Company has secured the necessary financial backing and that work will shortly be commenced. A New York concern is reported to have agreed to take $2,000,000 in stocks and bonds and reorganize the company.

DENVER, COL.—An electric lighting system is to be installed at Fort Logan. The work will cost $15,990. The Arapahoe Electric Light and Power Company will supply the necessary current, at the rate of $75 a year for arc lights and eight cents per kilowatt-hour for electric light and power.

SALEM, ORE.—There is a movement on foot to install another electric lighting plant in this city in the near future. The promoters are the stockholders of the Portland Flouring Mills Company, and the proposed plant will be located in the company's old building. It is understood that it is the intention of the company to put in a first-class lighting plant for the use of the city and the state.

LARAMIE, WYO.—At the annual meeting of the stockholders of the Laramie Electric, Gas Light and Fuel Company the following trustees were reelected: R. H. Homer, J. T. Holliday, J. H. Symons, Eli Crumrine, A. C. Jones, C. D. Spalding and E. D. Hiskey. The trustees afterward reorganized by the election of the following officers: president, R. H. Homer; vice-president, J. T. Holliday; secretary and manager, J. H. Symons; treasurer, Eli Crumrine.

GRIFFIN, GA.—The Towalaga Electric Power Company is pushing the work upon its plant at High Falls and expects to have the power in Griffin by next fall. The direct wires from this plant will be thirteen miles in length and they will carry 3,000 horsepower to the manufacturers of Griffin and vicinity. A dam and reservoir are being constructed at High Falls. The lake which will be formed by this dam will be three miles long and one mile wide.

WHEELING, W. VA.—The stockholders of the Moundsville Electrical Company held a meeting recently and elected the following officers for the ensuing year: S. M. Steele, C. R. Oldham, H. W. Thompson, B. B. McMechen, Fred. Kemple, J. T. Gallaher and T. S. Riggs. The board organized as follows: B. B. McMechen, president; Fred. Kemple, vice-president; T. S. Riggs, treasurer. The stockholders decided to install the most modern machinery in its plant, powerful enough to supply the city with arc lights in case the city desired them. If its present building is inadequate to hold the new machinery a new one will be built.

COLUMBUS, OHIO—At the annual meeting of the stockholders of the Columbus Railway and Light Company, the report presented showed a successful year's operation. The earnings were $126,000 in excess of those of the preceding year, 1902. The following directors were elected: R. E. Sheldon, E. K. Stewart, C. M. Clarke, G. W. Sinks, Theodore Rhodes, Charles H. Lindenberg and Carl J. Hoster. The directors reelected the following officers: president, R. E. Sheldon; first vice-president, general manager and treasurer, E. K. Stewart; second vice-president, C. M. Clarke; secretary-auditor, P. V. Burrington; general superintendent, M. S. Hopkins; assistant superintendent, L. G. White.

NEW INCORPORATIONS.

LANSING, MICH.—Atgansee Telephone Company, $5,000.

WILLS' POINT, MO.—Wills' Point Electric Light Company. $10,000. Incorporators: O. I. Johnson, Charles E. Brown and W. B. Rodgers.

ELGIN, ILL.—The Aurora, Elgin & Chicago Light, Heat and Power Company. $5,000. Incorporators: Edwin C. Faber, John T. Huntington and William F. Harvey.

FINDLAY, OHIO—Warren, Cortland & Jefferson Traction Company. $10,000. Incorporators: John Lendy, P. N. Taylor, A. H. Gebert, J. S. Morgan, George H. Pomeroy.

KANSAS CITY, MO.—Independent Telephone Construction Company. $100,000. Incorporators: J. E. Zeluff, Joseph J. Heim, J. S. Brailey, Jr., O. C. Snider, Hugh C. Ward, W. O. Polk and C. J. Myers.

TRENTON, N. J.—The Columbus Public Service Company. $1,500,000. Incorporators: Horace S. Gould, H. O. Coughlan, of New York; Jesph M. Mitchell, of Newark; B. S. Lantz, of Brooklyn, and Louis B. Dailey, of Jersey City.

PERSONAL MENTION.

MR. R. E. DANFORTH has been made general manager of the Rochester Electric Railway Company, Rochester, N. Y.

MR. E. O. SESSION has been appointed engineer of the western sales office of the Stanley Electric Manufacturing Company, with headquarters at Chicago, Ill.

MR. CARL HERING, a past-president of the American Institute of Electrical Engineers, has recently been elected president of the Engineers' Club, of Philadelphia, Pa.

MR. J. H. VAN BRUNT, general manager of the St. Joseph Railway, Light, Heat and Power Company, St. Joseph, Mo., has been elected vice-president of the company.

PROFESSOR F. B. CROCKER, of the electrical engineering department of Columbia University, New York city, N. Y., recently sailed with Dr. M. I. Pupin for a short trip in Mediterranean waters.

MR. ALFRED A. KNUDSON delivered a lecture on "The Corrosion of Metals Underground by Electrolysis" at the section meeting of the Franklin Institute, Philadelphia, Thursday evening, February 11.

MR. J. A. GORDON, formerly connected with the electrical engineering department of the Sterling Electrical Company, La Fayette, Ind., has tendered his resignation to take charge of the Lipton Telephone Company, Lipton, Ind.

MR. C. G. Y. KING, M. E., is to lecture before the General Electric agents, in New York city, on February 17, on the "Erection of a 5,000-Kilowatt Steam Turbine." Mr. King is a member of the engineering staff of the Chicago Edison Company.

PROFESSOR MORTIMER E. COOLEY has been appointed dean of the engineering department of the University of Michigan, to succeed the late Charles E. Green. Mr. Cooley was formerly professor of mechanical engineering at the university.

MR. E. W. McKENNA, formerly general superintendent of the eastern district of the Great Northern Railway Company, has accepted the position of assistant to the president of the Chicago, Milwaukee & St. Paul, with headquarters at Chicago, Ill.

MR. W. F. RICHARDSON has been transferred from the Cleveland, Ohio, branch of the John A. Roebling's Sons Company to the San Francisco branch of the company. Mr. Richardson was formerly assistant manager of the company's Cleveland office.

MR. S. N. HARRISON has been appointed superintendent of the Wisconsin & Michigan Railroad with headquarters at Peshtigo, Wis. Mr. Harrison has heretofore been superintendent of transportation, and under his new title he will have charge of operation and maintenance.

PROFESSOR F. E. TURNEAURE, of the University of Wisconsin, has been elected dean of the college of mechanics and engineering, to succeed the late J. B. Johnson. Professor Turneaure has been actively engaged in the teaching and practice of civil engineering since he graduated from Cornell University in 1899.

MR. W. L. HODGES, who for some time was associated with Dr. Louis Duncan, working principally in the telephone field and who has been recently located in Philadelphia, has been appointed manager of sales of the National Battery Company. Mr. Hodges has resigned as manager of the appraisement department of the Audit and Appraisement Company of America.

MR. JOHN McGEORGE, consulting engineer of the Welman-Seaver-Morgan Company, has tendered his resignation to take effect March 1. Mr. McGeorge has been connected with the company as mechanical engineer for the past thirteen years. It is expected that Mr. McGeorge will go to Cleveland, Ohio, where he will open an engineering office under the name of McGeorge & Sons, taking into partnership with him his sons.

DR. M. I. PUPIN has won a victory over the German postal authorities at Berlin and other places on his German patent covering his inventions in long-distance telephoning. The American rights to the invention have been sold to the American Bell Telephone Company, and arrangements were made for the sale of the foreign rights to the firm of Siemens & Halske, of Berlin, in the event that he could establish his patents. A contest was enjoined in German courts by several private concerns and has been waged for four years.

MR NIKOLA TESLA announces that in connection with the commercial introduction of his inventions, he will render professional services in the general capacity of consulting electrician and engineer. The near future, he states, will be a witness of revolutionary departures in the production, transformation and transmission of energy. These advances are certain to follow from the universal adoption of high-potential high-frequency currents, and involve regenerative processes of refrigeration to very low temperatures. Much of the old apparatus will have to be improved, and much of the new developed, and he believes that, while furthering his own inventions, he will be more helpful in this evolution by placing at the disposal of others the knowledge and experience he has gained. He will undertake experimental investigation and perfection of ideas, methods and appliances, the devising of useful expedients, and, in particular, the design and construction of machinery for the attainment of desired results.

ELECTRICAL SECURITIES.

A survey of the conditions of stock markets in various financial centres throughout the country shows very little but declines of various proportions. The situation is very much the same as it was during the latter period of last year. The sentiment which prevailed throughout the entire week was that an outbreak between Russia and Japan was imminent; and the unsettled condition of the market, due to the outlook for firmer money and the inevitable scare which would follow the involving of any of the greater nations in international difficulties, helped on what was already a bad enough tendency. One of the features of the week was the borrowing of $50,000,000 by the Pennsylvania Railroad for eighteen months, a loan which was floated on a 4½ per cent basis.

ELECTRICAL SECURITIES FOR THE WEEK ENDING FEBRUARY 6.

New York:	*Closing.*
Brooklyn Rapid Transit	40⅜
Consolidated Gas	189½
General Electric	168
Kings County Electric	184
Manhattan Elevated	142⅛
Metropolitan Street Railway	117½
New York & New Jersey Telephone	149
Westinghouse Electric	190

Brooklyn Rapid Transit directors have reelected officers.

Boston:	*Closing.*
American Telephone and Telegraph	125¼
Edison Electric Illuminating	235
Massachusetts Electric	77
New England Telephone	121
Western Telephone and Telegraph preferred	82

Directors of the Boston Elevated Railway have declared the regular semi-annual dividend of three per cent.

Philadelphia:	*Closing.*
Electric Company of America	8
Electric Storage Battery common	55
Electric Storage Battery preferred	55
Philadelphia Electric	6
Union Traction	47⅜
United Gas Improvement	85¼
Chicago:	*Closing.*
Chicago Telephone	120
Chicago Edison Light	150
Metropolitan Elevated preferred	50
National Carbon common	25
National Carbon preferred	94
Union Traction common	5½
Union Traction preferred	30

The total Lake Street Elevated traffic for January showed a daily average of 42,829, a decrease of 1,214.

Metropolitan Elevated for January had a daily average of passengers carried of 112,413, a decrease of 358.

A special meeting of the South Side Elevated has been called for April 7, to vote on the increase in the capital stock to $17,550,500.

The balance sheet of Northwestern Elevated as of December 31, 1903, shows total assets of $26,917,800, profit and loss surface, $674,263. The ratio of operating expenses to earnings for the year was 42.6 per cent.

TELEPHONE AND TELEGRAPH.

PALMER, IOWA—A rural telephone line will be built to Pomeroy next spring.

FRANKFORT, MICH.—The Bell Telephone Company has completed its line to Lake Ann.

ESTHERVILLE, IOWA—A new telephone exchange will probably be established in this town.

DES MOINES, IOWA—The Reinbeck Telephone Company will establish a local exchange at Reinbeck.

BEAUMONT, TEX.—The telegraph and telephone exchanges of Sour Lake have been destroyed by fire.

SODUS, N. Y.—The Wayne-Monroe telephone company is preparing to erect an exchange in this town.

DEPOSIT, N. Y.—The Bell Telephone Company will in the spring extend its line from Lanesboro to Forest City.

WHEELING, W. VA.—The People's Telephone Company will erect an exchange in Weston in the near future.

STREATOR, ILL.—It is stated that the Central Union Telephone Company will expend $25,000 in bettering the local system.

JACKSON, MICH.—A. Cantwell is interested in the construction of a telephone line between Chesaning, Mich., and Monroe.

MERCER, PA.—The Shearkleyville Telephone Company has been organized with H. Orr, president, and Le Roy Phillips, secretary.

ROME, N. Y.—The Utica Telephone Company has completed arrangements for the establishment of an exchange in Whitesboro.

WATKINS, N. Y.—The Century Telephone Company is now connected with Burdett, Bennettsburg, Reynoldsville and Mecklenburg.

BRYAN, OHIO—A deal has been consummated whereby the Bryan Telephone Company absorbs the Williams County Telephone Company.

FERNWOOD, OHIO—The Reed's Mills Telephone Company will build a line to connect Bloomfield Central, and also a line to connect with Unionport.

DAYTON, OHIO—A number of residents of New Lebanon and vicinity have organized a private telephone company, with W. E. Weaver as head.

SAMOKA VALLEY, N. Y.—The Dundee & Samoka Valley telephone line will give this village connection with Atlay, North Reading, Six Corners and other places.

JACKSON, MICH.—The Lake Shore Railroad is preparing to adopt a telephone system. The experiment will first be made between Mishawaka, Ind., and Chicago.

DUNDEE, N. Y.—It is stated that a new telephone company is soon to be organized, to be known as the Dundee, Rock Stream, Reading Center & Watkins Telephone Company.

JACKSON, MICH.—The management of the United States Telephone Company announces that it will soon begin the expenditure of half a million dollars on the lines leading out to Toledo.

MEMPHIS, TENN.—The Memphis Long-Distance Telephone Company has executed a $1,000,000 mortgage to provide funds to carry on and complete construction and acquisition of properties.

WATERLOO, IOWA—The Hudson Mutual Telephone Company has been organized with the following officers: president, H. B. Eighmey; vice-president, W. Cronover; secretary and treasurer, W. Gleney.

ZANESVILLE, OHIO—A new local telephone company is being formed and work is in progress, the plan being to take in the farmers in Guernsey County, or the section around Lore City, Hartford and Pleasant City.

DILLON, MONT.—The Rocky Mountain Bell Telephone Company is installing farmers' circuits in the immediate vicinity of Dillon, and will later extend this service to a large number of ranches in the valleys surrounding the town.

WHEELING, W. VA.—At a meeting of the stockholders of the National Telephone Company, Henry Schmulbach was elected president; J. J. Walsh, vice-president; Louis J. Bayha, treasurer, and W. C. Handlan, secretary and general manager.

MIDDLETOWN, N. Y.—At a meeting of the directors of the Orange County Telephone Company the following officers were elected for the ensuing year: president, Charles Higham; vice-president, A. B. Wilbur; secretary, W. C. Ramsdell.

WILMINGTON, N. C.—It is stated that the Bell Telephone Company will in the near future build a line from here to Florence, S. C., a distance of 110 miles. Such a line would connect the towns of Whiteville, Chadbourn, Fair Bluff, Mullins, Marion and Florence.

MONTPELIER, VT.—The Orange County Telephone Company has elected the following directors: C. L. Speare, West Corinth; G. Cane, Brookfield; E. H. Kennedy, Chelsea; H. S. Towne, Montpelier; M. W. Chamberlain, Washington; H. Waldo, Randolph; B. Dailey, Calais.

WASHINGTON, D. C.—It is stated that the Postal Telegraph-Cable Company contemplates placing all its wires in this city underground within the next twelve months, and that in order to do this, arrangements have been made with the telephone company for the use of one duct in its conduits.

PETERSBURG, VA.—The American Telephone and Telegraph Company is running its wires through Petersburg from Washington, D. C., to Denmark, S. C., and from Washington to Norfolk. The Petersburg Telephone Company has just completed a line from Petersburg to McKenney, in Dinwiddie County.

HOPKINSVILLE, KY.—The Hopkinsville Home Telephone Company has been organized, with the following officers: R. E. Cooper, president; George H. Metheany, of Lima, Ohio, vice-president; Joseph F. Garnett, treasurer, and F. G. Hoge, secretary. The company has awarded a contract for a complete telephone exchange.

WATERVLIET, MICH.—The Spinks Corners Telephone Company has been incorporated with a capital of $5,000. The officers are P. Yund, president; L. B. Millin, vice-president; L. Stewart, secretary; W. H. Hill, treasurer. The line will extend from Pearl Grange, where connection will be made with the Twin City line.

CANTON, PA.—The borough council has granted a franchise to the Canton & Leroy Telephone Company, which will install its system as soon as possible. It is also stated that the Bradford Telephone Company will build a line up the Tonawanda valley to Canton, to connect with its Williamsport line. A branch will be run to Troy.

ROCHESTER, N. Y.—There has been filed with the county clerk a mortgage by the Rochester Telephone Company to the Rochester Trust and Safe Deposit Company, as trustee for the bondholders, to cover an issue of bonds not to exceed $3,000,000, the money raised to be used in retiring other bonds and caring for expenditures.

SHELBYVILLE, IND.—The Mutual Telephone Company has placed a new section of switchboard in the exchange here, which gives connection to 1,100 patrons of the company. Another line will be placed in operation between this city and Indianapolis, as the two lines now in use are not sufficient to meet the demands for service.

KANSAS CITY, MO.—The officials of the Kansas City Home Telephone Company announce that arrangements have been made to run a long-distance line to Sedalia, where connection will be had with one that runs to St. Louis *via* Jefferson City. At the annual meeting of the company the following officers were elected: president, J. J. Heim; vice-president, Henry Koehler, Jr., St. Louis; second vice-president and treasurer, O. C. Snider; secretary, H. C. Ward.

PHILADELPHIA, PA.—At the annual meeting of the Keystone Telephone Company, held in Camden, N. J., it was reported that the gross earnings of the company were $481,524, and net earnings $232,515. Last year the company expended on extensions and increase of plant $947,590, and the increase in the number of telephones was 5,200. Three new exchanges have been opened, one in Germantown, supplying Germantown, Chestnut Hill and Manayunk. Directors John M. Mack, Michael Murphy, Jacob E. Ridgeway and Norman Grey were reelected.

ELECTRIC RAILWAYS.

ROCHESTER, N. Y.—The Buffalo & Depew Railroad is to extend its line to Rochester. It is believed that work on the extension will be begun in the spring and that the line will be open to traffic in the fall.

SISTERSVILLE, W. VA.—The Wetzel-Tyler Railroad Company has completed its large power plant at Paden City and is now transmitting the power for the running of its electric street cars. Power was formerly furnished by the Sistersville Electric Light and Power Company.

APPLETON, WIS.—W. H. Holcomb, J. A. Hayes, John L. Jacquet and Paul V. Cary have incorporated the Outagamie Traction Company to build an electric railway between Appleton, Hortonville and other cities. The necessary franchises have nearly all been secured.

McKEESPORT, PA.—The Monongahela Traction Company is making preparations for the building of its lines from West Newton to Jeannette. A great many of the rights of way have been secured, and it is expected that the work of construction will be begun with the early spring.

NORFOLK, VA.—A company has been chartered here to build an electric railway to Elizabeth City, N. C. The distance is forty miles and the route lies through rich trucking lands. It is said that the Norfolk City Railway, which is owned by the Williams Syndicate, of Richmond, is to build the road.

LANCASTER, PA.—Preliminary steps have been taken for the construction of a trolley line from Coatesville to Strasburg, by way of Christiana, Atglen, Green Tree and Georgetown, to connect with the Lancaster County trolley system at Strasburg. A committee has been appointed to look after the rights of way.

EAST ST. LOUIS, ILL.—Work has been begun on the new electric road connecting the Tri-Cities with Alton. The roadbed and the erection of the poles to carry the supply wires are to be completed within two months, according to the contract. A branch road from Mitchell to Edwardsville will also be constructed.

ELKHART LAKE, WIS.—Preparations are under way to push the work of grading and laying the tracks for the proposed Sheboygan-Elkhart Lake Electric Railway. The present electric powerhouse here will be remodeled into a 1,000-horse-power plant, which will also furnish electric light to this village. A 2,000-horse-power plant will be erected in Sheboygan.

HEREFORD, PA.—The right of way has been secured for a trolley link from Lyons to East Texas, along the East Penn Railroad, by the Reading & Allentown Street Railway Company. The link will connect with the Kutztown trolley line and will make a short circuit between Reading and Allentown, besides giving trolley communication to half a dozen towns.

ELMIRA, N. Y.—Announcement has been made that arrangements have been concluded for the building of a third-rail street car system between this city and Corning. The necessary application will be made to the state railroad commissioners for permission to construct the line. A private right of way has been secured and only one grade crossing will be made.

WILMINGTON, DEL.—The Wilmington & New Castle Electric Railway Company, operating a line between this city and New Castle, and the New Castle & Delaware City Railway Company, operating a line between New Castle and Delaware City, are to be consolidated and merged into a new company, to be known as the Wilmington, New Castle & Southern Railway Company.

AUSTIN, TEX.—The project of an electric line between Belton and Temple, Tex., is said to be taking tangible shape. The franchise is held by J. C. Houser and associates of Readsville, Pa. The road will be known as the Temple & Belton Interurban, and its officers are Samuel Watts, president; A. F. Bentley, vice-president; A. C. Mayers, second vice-president; W. H. Taylor, third vice-president; Calvin Greene, treasurer; J. C. Houser, secretary.

GREENSBURG, PA.—The Greensburg & West Newton Street Railway Company, which has projected a line from the southwestern end of Westmoreland County to Greensburg, will begin work of construction in the spring. Almost all the rights of way have been secured, and connection will be made with the Pittsburg, McKeesport & Greensburg line. The line will open up a rich mining district, touching Grapeville, Adamsburg, Arona, Madison and West Newton.

ALBANY, N. Y.—The Electric City Railway Company, of Niagara Falls, has been incorporated to operate a street surface electric road eight miles long in Niagara Falls. The capital stock is $80,000, and the directors are: Alvah K. Potter, of Lockport, and Arthur Schoellkoff, James S. Simmons, Henry H. Findlay, S. P. Franchot, Patrick F. King, Henry L. Colpays, Frank E. Reid and Frederick J. Brown, of Niagara Falls.

LOS ANGELES, CAL.—It is announced that the Pacific Electric Railway will at once complete the double tracking of the Monrovia line from San Marino station to Arcadia and thence to Monrovia. The East Colorada street line in Pasadena will also be extended to Lamanda Park, where it will join with a spur from the Monrovia line, making a loop by which Pasadenans can make the shorter trip to either Lamanda or Monrovia and to Los Angeles by that route if they so desire.

UTICA, N. Y.—It is stated that work will shortly commence on an extensive system of electric roads in the North Woods. The first step in the projected enterprise will be the building of a line connecting Upper St. Regis Lake and Lake Clear with Paul Smith's. The power for the proposed road will be taken from Franklin falls, in the Saranac river, twenty miles away. It is understood that the plans provide for the connection of Saranac Lake with all the villages thereabouts, as well as with this city.

HAZLETON, PA.—The ordinance granting the Hazleton, Weatherly & Mauch Chunk Traction Company the right of way through a section of that city has been signed, and work on the construction of the line will be commenced early next spring. It is the expectation of the officials of the company to have cars running between Hazleton and Weatherly, a distance of twelve miles, by July 4. With the completion of the road it will be possible to travel by trolley from Hazleton to Tamaqua and Lehighton. At the latter place connections will soon be made for Allentown.

TOLEDO, OHIO—Papers of incorporation have been granted by the secretary of state of Georgia to E. H. Van Wey, of Toledo, J. B. Dortch, B. F. Alderholde, W. R. Brown and others composing the stockholders in the Cartersville (Georgia) Traction Company. This company proposes to build an electric railway from Cartersville in Franklin County, through Madison and Clarke counties, to Athens, the line to be between thirty and forty miles in length. The capital stock of the company is half a million dollars, and Mr. E. H. Van Wey, the Toledo stockholder, is vice-president of the company. Surveys are practically completed and the work of grading is in progress. Tracks will be laid in the spring and the road completed during the summer months.

ST. LOUIS, MO.—Articles of incorporation have been filed at Springfield, Ill., by the St. Louis, Granite City & Alton Traction Company, with a capital of $150,000. The incorporators and members of the first board of directors are: David R. Francis and F. E. Allen, of St. Louis; George Miller, of Venice, and W. M. Warnock and Harrison Barco, of Edwardsville. The principal offices, yards and power-houses will be located at Granite City. The line will have its southern terminus at East St. Louis. It will run through the railroad yards to Venice. From that point it will go to Granite City, passing through Madison and Furguson. From Granite City it will run to Edwardsville. From that town it will run direct to Alton.

RUSHVILLE, IND.—The Indianapolis & Cincinnati Traction Company has been granted an extension of time on its franchise for the building of the line from Indianapolis to this city. The company stated that at a meeting of the directors it had been decided to equip the cars with alternating motors, which would mean about six or eight months longer for the completion of the equipment. Each motor has a capacity of 475 horse-power, and these will give the cars practically no limit of speed. It was first decided by the directors to build the third-rail system, but later they decided to use the trolley system with the alternating current, which will give much better speed. Work will be pushed as rapidly as possible. It is believed that cars will be running between Indianapolis and Rushville by August 1.

INDUSTRIAL ITEMS.

THE SPRAGUE ELECTRIC COMPANY, New York city, will be pleased to send its new bulletin describing M. L. engine-type direct-current generators. Those desiring this should write for bulletin No. 105.

THE MARSHALL-SANDERS COMPANY, Boston, Mass., is calling especial attention to its new line of imported slate base baby knife switches with copper contacts. Critical attention of users of the material is invited.

THE NORTON ELECTRICAL INSTRUMENT COMPANY, INCORPORATED, Manchester, Ct., is distributing a new price list on Norton ammeters and voltmeters. This apparatus is made in several styles and catalogue will be sent upon request.

THE CROCKER-WHEELER COMPANY, Ampere, N. J., in bulletin No. 40 describes a ten-ton revolving trolley ingot charging crane. This machine uses five form K motors for the various movements. The bulletin will be sent on request to those interested.

THE CENTRAL ELECTRIC COMPANY is sending out a circular which quotes attractive prices on American Circular Loom flexible conduit, for which it is sales agent. The company is also sales agent for Edison primary batteries, and is prepared to make immediate shipments from a large stock.

THE C & C ELECTRIC COMPANY, 143 Liberty street, New York city, is distributing two new bulletins. One of these presents a list of users and some of the principal installations of C & C dynamos and motors. The other bulletin describes the C & C multipolar type "MP" dynamos and motors.

THE CRESCENT ELECTRICAL MANUFACTURING COMPANY, Rochester, N. Y., manufacturer of switches, cutouts, porcelain sockets and electrical supplies, will be pleased to send its descriptive catalogue on request. This catalogue gives the prices and descriptions of the line of apparatus manufactured by this company.

THE DONGAN INSTRUMENT COMPANY, 100 State street, Albany, N. Y., in bulletin No. 4 describes a line of switchboard voltmeters and ammeters. Half-tone illustrations are shown of the various types of meters manufactured by this company, and there are also illustrations of the various scales fitted to these instruments.

THE STERLING-MEAKER COMPANY, Newark, N. J., is distributing in attractive form the report of the president and treasurer and the minutes of the fourth annual meeting of the stockholders. This report shows in detail the present standing of the company, and the distribution of its voting shares, with the general staff organization.

THE EMERSON ELECTRIC MANUFACTURING COMPANY, St. Louis, Mo., has published an attractive catalogue descriptive of its line of fan motors for 1904. This includes desk fans for high and low frequency current, bracket fans, ceiling fans, column fans and exhaust fans. The company also manufactures a line of exhaust fans for direct current.

THE WHITE STAR APPLIANCE COMPANY, 316 Potomac avenue, Buffalo, N. Y., announces that its duplex mast arm is meeting with great success. The Buffalo Specialty Manufacturing Company, Buffalo, N. Y., is handling this material, and it is being widely used in the United States and Canada. Mr. J. J. Shickluna is the proprietor of the White Star Appliance Company.

THE S. R. SMYTHE COMPANY, Pittsburg, Pa., represented in New York city by Dr. Oskar Nagel, 90 Wall street, has issued a catalogue on suction gas producers for gas engines, showing the simplicity and advantages of the construction, and economy in fuel attained. These producers are built in units from 5 to 150 horse-power, and yield one horse-power-hour per pound of coal. No boiler or gas-holder is required.

THE SMITH STORAGE BATTERY COMPANY, Binghamton, N. Y., describes its storage battery types in a new catalogue which it will be pleased to send to those interested. This company is the manufacturer of the "Troy" type of storage battery, for which the company claims a number of remarkable properties. The catalogue is skilfully illustrated and the reading matter deals carefully with the construction and operation of the batteries.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has established a draughting-room apprenticeship course, to which young men who are able to pass satisfactorily an examination in arithmetic are eligible. The course is intended to fit applicants for draughting-room positions. Further information can be obtained from Mr. J. W. Upp, engineer in charge of the draughting room, General Electric Company, Schenectady, N. Y.

THE WESCO SUPPLY COMPANY, St. Louis, Mo., will be pleased to send to all of the trade its new catalogue upon request. In addition to the latest market prices on all articles shown in this book, there are shown several lines of new goods, and, in addition to this, a copy of the latest rules of the National Board of Fire Underwriters. These rules will be found very useful as a ready reference, and the Wesco company has inserted them for the special convenience of its customers.

THE C. W. HUNT COMPANY, West New Brighton, Staten Island, N. Y., in catalogue 038 gives a complete exposition of its narrow-gauge "Industrial" railway systems. This gives the manufacturer who needs a railway for handling material the important points of information on the subject of what gauge is best for the purpose, the radius curves to be used, the weight of rail, the style of cars best suited for the purpose, the kind of cross-ties, the way switches and crossings should be made, where turn-tables can be avoided, and where a locomotive may be used.

THE FORT WAYNE ELECTRIC WORKS, Fort Wayne, Ind., manufacturer of the "Wood" systems of electrical machinery, is mailing instruction books Nos. 3018 and 3019, treating, respectively, of enclosed alternating-current multiple system "Wood" arc lamps, special transformer type C, and enclosed alternating-current 104-volt "Wood" arc lamps, multiple type form C. Two bulletins which this company is also distributing describe multiple alternating-current street arc lighting systems, and give a list of plants operating its single-phase alternators in the United States on December 1, 1903.

THE H. W. JOHNS-MANVILLE COMPANY, 100 William street, New York city, has produced an asbestos theatre curtain which is in use in a number of the most prominent theatres in the country. This curtain is made of pure asbestos, and into the curtain are woven strands of brass wire which has sufficient tensile strength to withstand the wind blast common to theatre fires. The wire also protects the curtain from puncture by falling timbers. The Johns-Manville Company will be pleased to send samples for test, and quote prices from any of its branches, upon hearing from persons interested.

I. P. FRINK, 551 Pearl street, New York city, is very busy filling orders for the special patent window reflector. This reflector is composed of silvered, corrugated glass, set in a metal frame, designed on thoroughly scientific lines, so that all the light is reflected on the goods, the lamp being perfectly hidden from the sidewalk. With the advancing improvement in window decoration and illumination, one of the most popular forms of window lighting is the distribution of a strong light from a concealed lamp. The Frink patent window reflector gives an opportunity of making the show-window decoration especially attractive.

THE WESTERN DISPLAY COMPANY, 321-325 Robert street, St. Paul, Minn., is one of the most extensive manufacturers of electric advertising sign devices. A new type of sign designated as the "Reflectric" is a novelty of peculiar merit. This consists of a galvanized iron hood or frame with properly disposed reflecting surfaces, with the lettering on the outside of the frame and on the hanger so arranged as to be highly illuminated; and at the same time attention is positively called to the device by the intense beams of reflected light. The apparatus is water-proof and can be kept clean and in perfect condition with very little care.

THE STANDARD UNDERGROUND CABLE COMPANY, Pittsburg, Pa., recently held its annual conference of the branch office managers with the general sales, the manufacturing, construction and executive departments of the company. This conference included a three days' session. The reports of each manager for the year 1903, and the business prospects for the year 1904, were presented and discussed, together with ways and means for rendering more efficient service in every department to the customers of the company. A pleasant social feature of the occasion was a theatre party given by Mr. J. W. Marsh, vice-president and general manager, to the visiting managers. Branch office managers attending the meeting were Mr. Charles J. Marsh and Mr. George L. Wiley, from the New York office; Mr. Frank Clark Crosby, from the Boston office; Mr. T. E. Hughes, from the Philadelphia office, and Messrs. J. R. Wiley and E. J. Pietzcker, from the Chicago office.